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COMPUTER REDUCTION OF PRECIPITATION DATA //

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COMPUTER REDUCTION OF PRECIPITATION DATA

George H. Comer and W. Russell Hamon[1]

Abstract

A program has been developed for the IBM 1620 computer for reduction of digitized precipitation data into useful quantities for analysis and reporting. The input format used with the program is designed to handle manually transcribed data or data punched by an automatic chart reader from Weather Bureau-type recording rain gage charts. For maximum flexibility, specific sections of the program may be bypassed. Each type of output has a code unique to that group.

Flow diagrams, program listings, and complete instructions for using the program are included.

Introduction

The reduction of precipitation data from the analog form, as obtained from the Weather Bureau-type recording rain gage, to quantities needed for analysis and reporting is a tedious and time-consuming task. Such reduced data are essential in the study of runoff rates, water yields, sedimentation, and other hydrologic research. In a well-organized and comprehensive program of such hydrologic investigations, large volumes of precipitation data must be processed; and the electronic computer has great utility in such a task.

This publication describes a computer program developed to enable the IBM 1620 computer to perform all the calculations required in reducing the precipitation data. The program is basically the same as that developed by Comer,[2] with some additions and refinements incorporated in the new program. Although the program described herein was written for the IBM 1620 computer, the methods and principles used could be employed to develop similar programs for other computers.

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[1] Agricultural engineer Northeast Branch, Danville, Vt.; and research agricultural engineer, Southern Branch, Oxford, Miss., Soil and Water Conservation Research Division, Agricultural Research Service, USDA, respectively.

[2] Comer, George H. Computer analysis of rainfall. Unpublished M. S. thesis, Newman Library, Virginia Polytechnic Institute, Blacksburg, Va., 1961.

Data Processing Requirements

The source of the raw data and the input and output formats were basic considerations in writing the computer program. The input format was designed to provide an easy means of transcribing the analog or chart data by both manual and automatic means into a form usable by the computer. The output format was arranged to contain all the desired reduced precipitation data in a form easily understood for direct use and appropriately identified for use as input data to computer analysis programs.

Another important consideration was program flexibility. The largest single expense in reducing the precipitation data is the cost of computer time. Any time used in computing data not required is an unnecessary expense. To eliminate such expenses and the need for several programs, the program was written with provision to bypass specific sections.

The following were used as the basis for the program:

1. Compute the intensity and amount of precipitation for each time interval during a storm when the intensity may be assumed as constant.
2. Compute running totals of precipitation for each storm, day, and month.
3. Compute the time between storms, with storms determined according to item 7 below.
4. Compute for each storm of 0.25 inch or more of precipitation the maximum intensities of precipitation during the storm for periods of 2, 5, 10, 15, 20, and 30 minutes and 1, 2, 4, 6, 12, and 24 hours.
5. Compute the amounts of precipitation for any three of the regular time periods of 1, 2, 3, 5, 6, 10, 15, 30, or 60 minutes.
6. Compute the total time of actual precipitation for each month and for each year.
7. Separate storms by periods of 1 hour or more during which no precipitation occurred, with provision to change this requirement from storm to storm by input coding.
8. Eliminate the necessity to start each period of precipitation at zero chart depth reading by providing for direct reading of rain gage recorder charts.
9. Provide for transcribing the input data by manual means or by automatic chart reader.
10. Code and number the output data to facilitate automatic handling of the data.

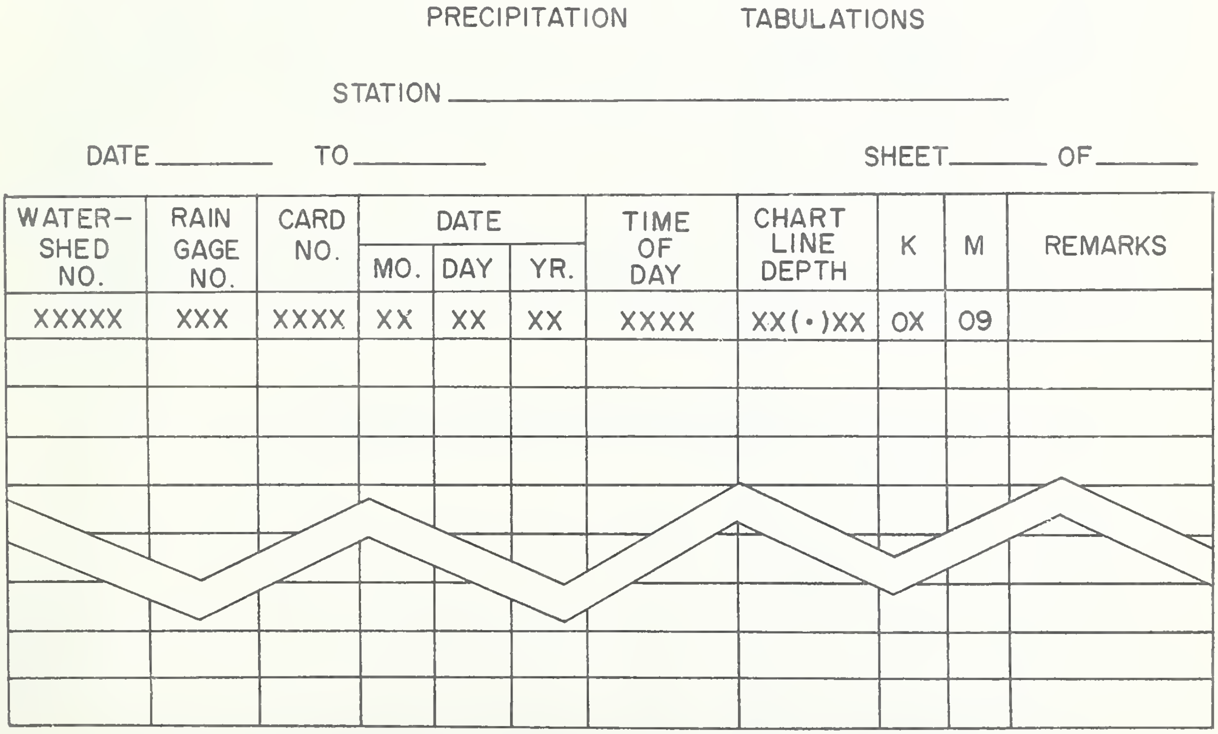
The Computer Program

The Symbolic Programing System (SPS) was chosen as the language to be used in writing the precipitation program because it gives a flexible program that is easily altered. It is also the easiest method of writing in fixed point arithmetic.

A complete listing of the program source deck is included as appendix 1; the compressed precipitation program deck is listed as appendix 2; and the flow diagram is shown as appendix 3.

A standard IBM 1620 computer with 20, 000-digit storage capacity and automatic division feature can process a storm with a maximum of 1, 260 lines of input data covering a maximum duration of 166 hours and 38 minutes.

The input format used with this program is designed to handle manually transcribed data or data punched by an automatic chart reader with a freely variable X origin offset and scale control ranging from -999 to +999. Thirty columns (thirty-one with 12-hour charts as punched with the automatic chart reader) of input data are used. Figure 1 shows a sample form for manual listing of the input data. The keypunch operator punches these data in input cards.



PRECIPITATION TABULATIONS

STATION ____________________

DATE ________ TO ________ SHEET ______ OF ______

WATER-SHED NO.	RAIN GAGE NO.	CARD NO.	DATE			TIME OF DAY	CHART LINE DEPTH	K	M	REMARKS
			MO.	DAY	YR.					
XXXXX	XXX	XXXX	XX	XX	XX	XXXX	XX(•)XX	0X	09	

FIGURE 1. --Sample form for manual listing of input data; K column designates separation of storms; M column designates method used to transcribe input data.

The input card formats with sample data punched are shown in figure 2. Columns 1 to 5 contain the watershed number. The first two columns represent

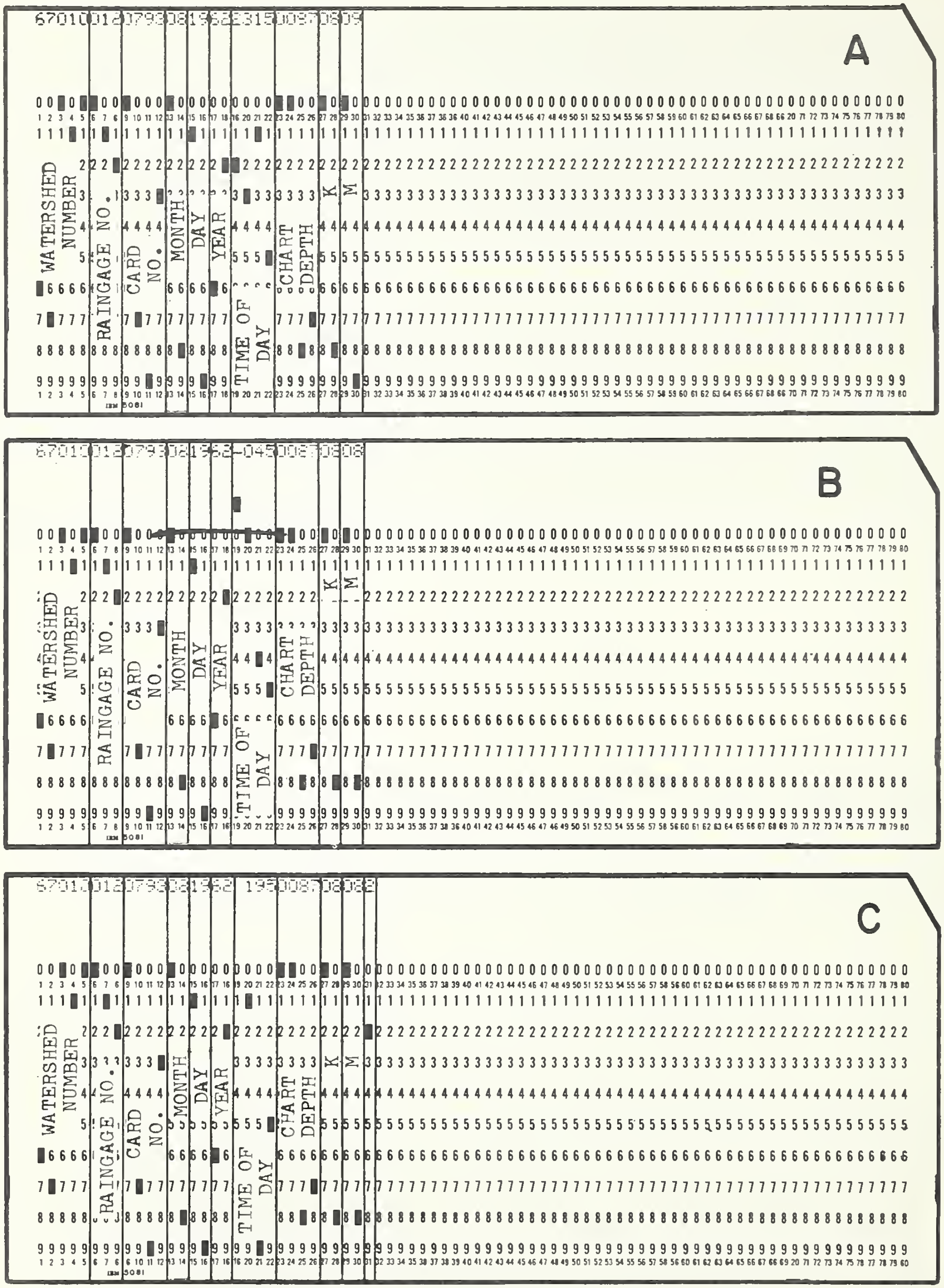


FIGURE 2. --Input data cards with same data: A, Punched from manually transcribed data; B, punched by a chart reader from a 24-hour chart; and C, punched by a chart reader from a 12-hour chart.

"location" identifiers, corresponding to the page Nos. of the USDA-ARS Hydrologic Data Releases, with columns 3 to 5 denoting the watershed in which the rain gage is located or situated nearest. Columns 6 to 8 contain the rain gage No., and columns 9 to 12 contain the card number which may be ignored but, when punched, affords an easy means of restoring the input data to its proper order when disturbed.

The date (month, day, and year) of the reading is entered in columns 13 to 18 and the time of day in columns 19 to 22. If the data are manually transcribed and punched, the time columns contain the time of day in military time. In case the automatic chart reader is employed with the 24-hour recording rain gage chart as shown in figure 3, the setup below is used.

24-hour Rain gage Charts (fig. 2, B)

Time	Columns			
	[1] 19	20	21	22
8:00 a.m.	-	9	6	0
12:00 noon	-	7	2	0
1:00 p.m.	-	6	6	0
12:00 midnight	-	0	0	0
12:01 a.m.	b	0	0	1
7:59 a.m.	b	4	7	9

---

[1] The symbol "b" denotes blank column.

For the 12-hour recording rain gage chart where the time of chart beginning is noon and midnight, the setup below is used.

12-hour Rain gage Charts (fig. 2, C)

Time	Columns				
	[1] 19	20	21	22	[2] 31
8:00 a.m.	b	0	0	0	1
12:00 noon	b	2	4	0	1
7:59 p.m.	b	7	1	9	1
8:00 p.m.	b	0	0	0	2
12:00 midnight	b	2	4	0	2
12:01 a.m.	b	2	4	1	3
7:59 a.m.	b	7	1	9	3

---

[1] The symbol "b" denotes blank column.
[2] Column 31 is used only for a time code with 12-hour charts.

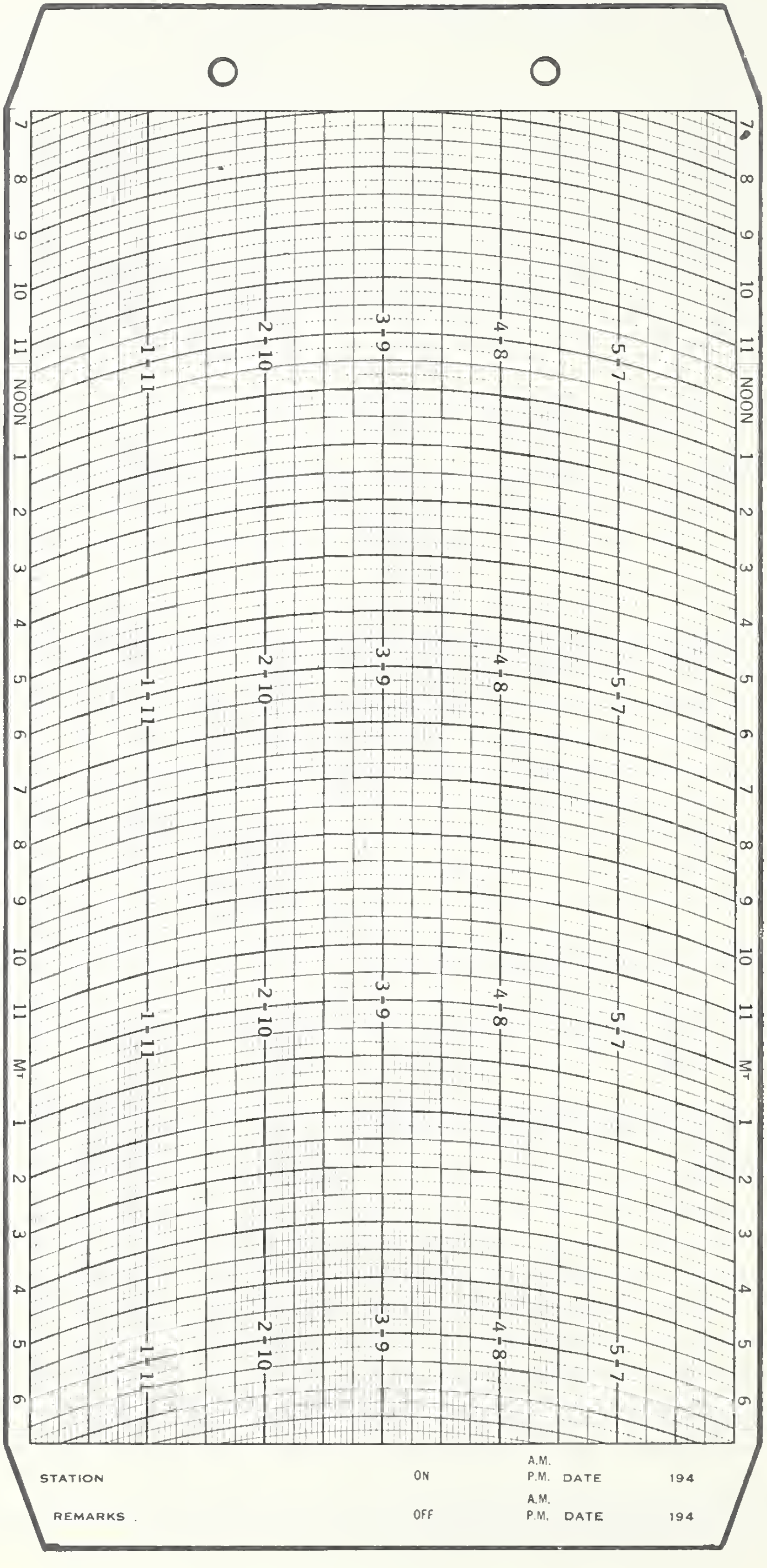


FIGURE 3. --Sample of recording rain gage chart (24-hour).

The chart line depth in inches is contained in columns 23 to 26. This depth is taken at the time recorded in columns 19 to 22. The decimal shown in figure 1, under chart line depth, is understood and not punched.

The K columns (columns 27 and 28) of the card are used to designate the separation of storms according to the following coding system:

07--The computer will consider this reading as the first reading of another storm regardless of the time interval between reading or the amount of precipitation occurring since the previous reading. This code causes the computer to consider the previous reading as the end of a storm.

08--The computer separates the events as programmed. (Any two periods of precipitation separated by 1 hour or more with no additional precipitation between are considered as separate storms.)

09--The computer will consider this reading as part of the same storm regardless of the time interval or amount of precipitation occurring since the previous reading.

The M columns (columns 29 and 30) are used to designate the method used to transcribe the input data. An 08 code indicates input from a chart reader; a 09 code indicates the data were manually transcribed and punched.

The output data consist of five types: (1) Output for each input reading, (2) extra output giving amounts of precipitation for regular time periods, (3) maximum storm intensities, (4) monthly summaries, and (5) yearly summaries. Each type of output has a code unique to that group.

The output data are punched in logical order and each output card is numbered to facilitate automatic sorting and other automatic data handling procedures.

The program may be considered as a combination of three separate parts. Provision is made for using the following combinations of the three parts:

1. Part 1 only.
2. Parts 1 and 2.
3. Parts 1 and 3.
4. Parts 1, 2, and 3.

Part 1 of Program

Part 1 of the program computes the intensity and amount of precipitation for each time interval and accumulates the total precipitation for each storm, day, and month. It also computes monthly and yearly summaries and the number of hours of no rain between storms.

The output of part 1 contains the following data:

1. Watershed No. and rain gage No., columns 1 to 8.

2. Date (month, day, and year), columns 9 to 14.

3. Time of day (military time), columns 15 to 20.

4. Time interval (hours and minutes), columns 21 to 28.

5. Intensity for the time interval in inches per hour accurate to four decimal places, columns 29 to 34.

6. Amount of precipitation for the time interval in inches, accurate to two decimal places, columns 35 to 40.

7. Accumulated amounts of precipitation for storms, days, and months in inches accurate to two decimal places, columns 41 to 58.

8. A code (0--numeric zero) as "blank" from IBM 407 accounting machine, column 59.

9. The sequential card number, columns 75 to 78.

Part 1 of the program leaves 17 columns of the standard 80-column card unused. Fifteen of these columns (60 to 74) are used for the output from part 3 when it is used. The two remaining columns (79 and 80) are not used.

At the end of each month a summary card is punched. It contains the data indicated below:

1. Watershed No. and rain gage No., columns 1 to 8.

2. Month and year, columns 9, 10, 13, and 14.

3. Time of actual precipitation during the month (hours and fractions of hours), columns 21 to 28.

4. The total amount of precipitation for the month (inches), columns 53 to 58.

5. A code (6) column 59.

6. The sequential card number, columns 75 to 78.

A similar summary card is punched at the end of each group of data processed (yearly summary card). This card contains the same type of information. The time duration of precipitation and the amount of precipitation are for the period covered by the data being processed. The "year" only is listed in the date columns.

The first output card punched at the beginning of each storm contains the number of hours since the end of the previous storm or the hour of no rain between storms.

Part 2 of Program

Part 2 of the program determines maximum precipitation intensities for each storm of 0.25 inch or more of precipitation. These storms are called storm events. The following information is punched in these output cards:

1. Watershed No. and rain gage No., columns 1 to 8.
2. Date of storm ending (month, day, and year), columns 9 to 14.
3. The maximum intensities for 2, 5, 10, 15, 20, and 30 minutes, all in inches per hour accurate to four decimal places, columns 21 to 58.
4. A code (9), column 59.
5. The sequential card number, columns 75 to 78.
6. The storm event number, columns 79 and 80.

A second card is punched containing the same data except the maximum intensities are for 1, 2, 4, 6, 12, and 24 hours, columns 21 to 58.

Part 3 of Program

Part 3 of the program computes precipitation amounts for three regular time periods. The program is written so that each time period will have an ending time every hour, clock time. For example:

Consider a rainfall that begins at 1:38 a.m. and the three regular time intervals being used are 15, 30, and 60 minutes. The time intervals are then as follows:

15-minute intervals--1:30-1:45
1:45-2:00
2:00-2:15

30-minute intervals--1:30-2:00
2:00-2:30
2:30-3:00

60-minute intervals--1:00-2:00
2:00-3:00
3:00-4:00

The output for this part of the program occupies 15 of the card columns not used by part 1 (columns 60 to 74). The data contained in these columns are as follows:

1. The amount for the first regular time period in inches accurate to three decimal places, columns 60 to 63.
2. The amount for the second regular time period in inches accurate to three decimal places, columns 64 to 67.
3. The amount for the third regular time period in inches accurate to two decimal places, columns 68 to 70.

4. The time of ending of period (military time), columns 71 to 74.

If no regular time period is completed during the time interval between readings, these columns are not used. When more than one of any regular time period can be accumulated between chart readings, extra cards are punched containing:

1. Watershed No. and rain gage No., columns 1 to 8.
2. Date (month, day, and year), columns 9 to 14.
3. Time of day of period ending (military time), columns 15 to 20.
4. A code (5), column 59.
5. The precipitation amounts for the three regular time periods, columns 60 to 70.
6. The time of ending of period (military time), columns 71 to 74.
7. The sequential card number, columns 75 to 78.

At the end of each storm an extra card of the same form is punched giving the accumulation in each regular time period from the previous period until the storm ending.

The program as listed in appendix 2 will compute the precipitation amounts for the regular time periods of 15, 30, and 60 minutes. To compute the amounts for the regular time periods of 5, 10, and 15 minutes, the card number "10" of the compressed program deck listing (appendix 2) must be replaced by a card of the form shown in figure 4, A. Similarly, computations for time periods of 2, 5, 10 minutes may be accomplished by substituting a card of the form shown in figure 4, B.

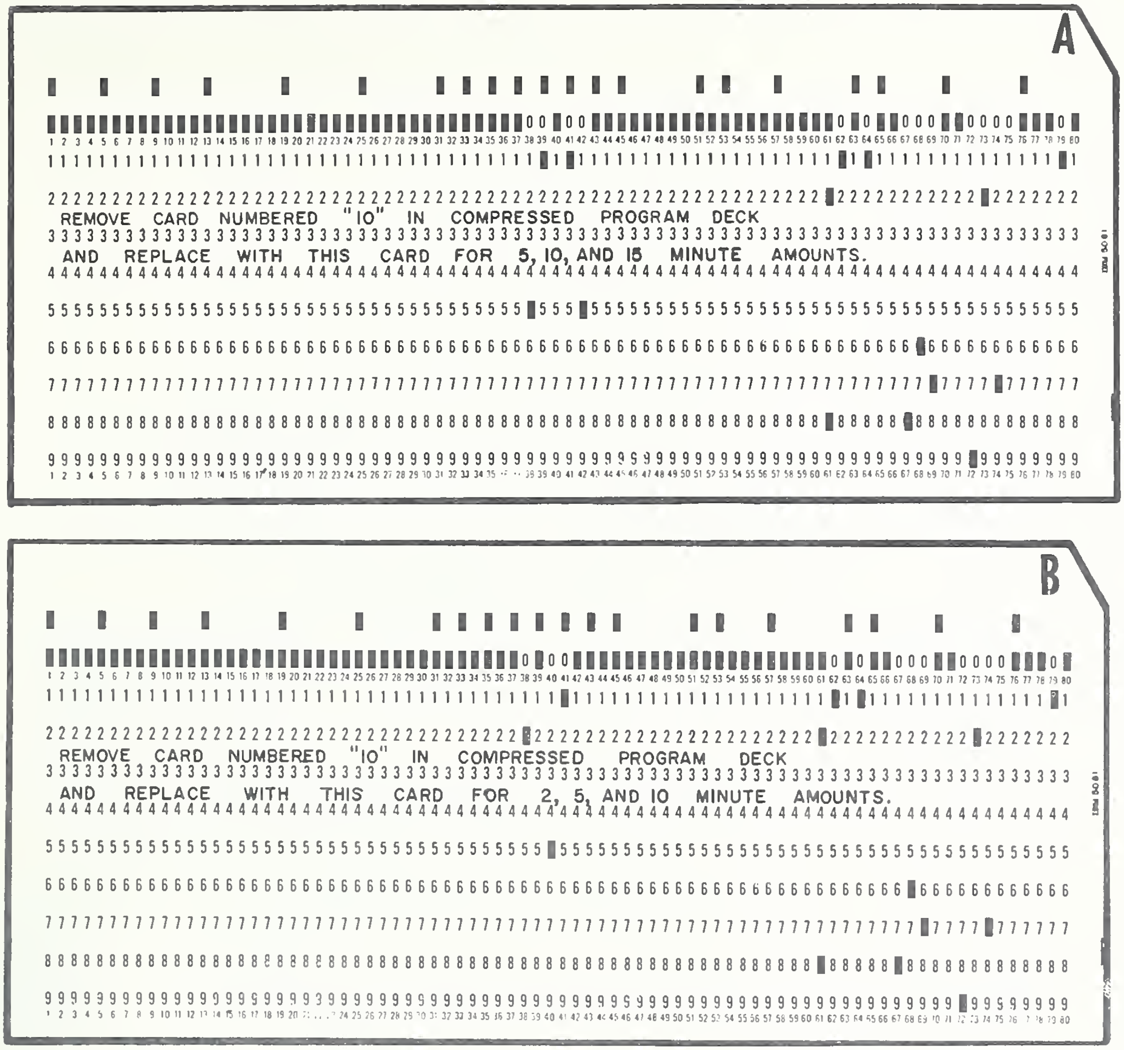
A sample of the output listed by an IBM 407 accounting machine is shown in figure 5. To list this data the panel board for the 407 must be wired for the data. The wiring diagram for the panel board is included as appendix 4.

Header Card

The header card (fig. 6) is used to set up the output area.

When part of a year of data is processed, a different header card should be used in computing the remaining data for the year. The header card for this case would be punched as follows:

1. Duplicate the output card corresponding to the last input card except the card No.
2. Make the card No. the same as the card No. of the last output card.
3. Use this card as the header to process the remaining data in that year.



REMOVE CARD NUMBERED "10" IN COMPRESSED PROGRAM DECK AND REPLACE WITH THIS CARD FOR 5, 10, AND 15 MINUTE AMOUNTS.

REMOVE CARD NUMBERED "10" IN COMPRESSED PROGRAM DECK AND REPLACE WITH THIS CARD FOR 2, 5, AND 10 MINUTE AMOUNTS.

Figure 4. --Form of program card required to compute precipitation amounts for regular time periods of: A, 5, 10, and 15 minutes; B, 2, 5, and 10 minutes.

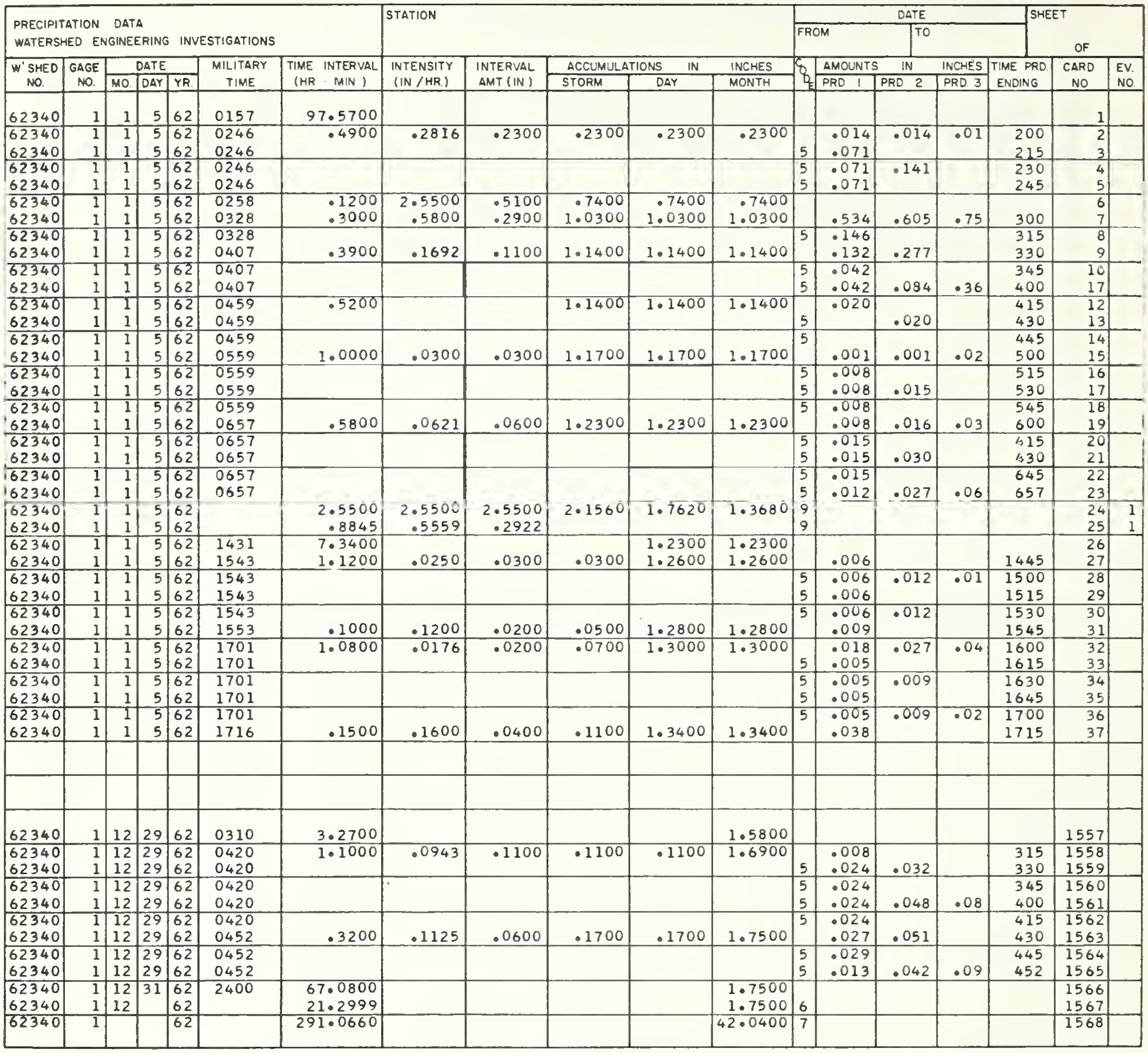
Trailer Card

The trailer card will be punched in either of two ways, depending on the last input card.

If the last input card is the last reading of a storm, the trailer card will be blank with the exception of "9" punches in columns 79 and 80 (type 1 trailer card). When the last input card is not the end of a storm, the trailer card is blank except column 80 contains a "9" punch (type 2 trailer card).

First Reading in the Year

The first reading in each group of data being processed must have a chart line depth reading of zero.



PRECIPITATION DATA
WATERSHED ENGINEERING INVESTIGATIONS

STATION

DATE FROM TO

SHEET OF

W'SHED NO.	GAGE NO.	DATE			MILITARY TIME	TIME INTERVAL (HR · MIN)	INTENSITY (IN /HR.)	INTERVAL AMT (IN)	ACCUMULATIONS IN INCHES			CODE	AMOUNTS IN INCHES			TIME PRD. ENDING	CARD NO	EV. NO.
		MO.	DAY	YR.					STORM	DAY	MONTH		PRD 1	PRD 2	PRD 3			
62340	1	1	5	62	0157	97.5700											1	
62340	1	1	5	62	0246	.4900	.2816	.2300	.2300	.2300	.2300		.014	.014	.01	200	2	
62340	1	1	5	62	0246							5	.071			215	3	
62340	1	1	5	62	0246							5	.071	.141		230	4	
62340	1	1	5	62	0246							5	.071			245	5	
62340	1	1	5	62	0258	.1200	2.5500	.5100	.7400	.7400	.7400						6	
62340	1	1	5	62	0328	.3000	.5800	.2900	1.0300	1.0300	1.0300		.534	.605	.75	300	7	
62340	1	1	5	62	0328							5	.146			315	8	
62340	1	1	5	62	0407	.3900	.1692	.1100	1.1400	1.1400	1.1400		.132	.277		330	9	
62340	1	1	5	62	0407							5	.042			345	10	
62340	1	1	5	62	0407							5	.042	.084	.36	400	17	
62340	1	1	5	62	0459	.5200			1.1400	1.1400	1.1400		.020			415	12	
62340	1	1	5	62	0459							5		.020		430	13	
62340	1	1	5	62	0459							5				445	14	
62340	1	1	5	62	0559	1.0000	.0300	.0300	1.1700	1.1700	1.1700		.001	.001	.02	500	15	
62340	1	1	5	62	0559							5	.008			515	16	
62340	1	1	5	62	0559							5	.008	.015		530	17	
62340	1	1	5	62	0559							5	.008			545	18	
62340	1	1	5	62	0657	.5800	.0621	.0600	1.2300	1.2300	1.2300		.008	.016	.03	600	19	
62340	1	1	5	62	0657							5	.015			415	20	
62340	1	1	5	62	0657							5	.015	.030		430	21	
62340	1	1	5	62	0657							5	.015			645	22	
62340	1	1	5	62	0657							5	.012	.027	.06	657	23	
62340	1	1	5	62		2.5500	2.5500	2.5500	2.1560	1.7620	1.3680	9					24	1
62340	1	1	5	62		.8845	.5559	.2922				9					25	1
62340	1	1	5	62	1431	7.3400				1.2300	1.2300						26	
62340	1	1	5	62	1543	1.1200	.0250	.0300	.0300	1.2600	1.2600		.006			1445	27	
62340	1	1	5	62	1543							5	.006	.012	.01	1500	28	
62340	1	1	5	62	1543							5	.006			1515	29	
62340	1	1	5	62	1543							5	.006	.012		1530	30	
62340	1	1	5	62	1553	.1000	.1200	.0200	.0500	1.2800	1.2800		.009			1545	31	
62340	1	1	5	62	1701	1.0800	.0176	.0200	.0700	1.3000	1.3000		.018	.027	.04	1600	32	
62340	1	1	5	62	1701							5	.005			1615	33	
62340	1	1	5	62	1701							5	.005	.009		1630	34	
62340	1	1	5	62	1701							5	.005			1645	35	
62340	1	1	5	62	1701							5	.005	.009	.02	1700	36	
62340	1	1	5	62	1716	.1500	.1600	.0400	.1100	1.3400	1.3400		.038			1715	37	
62340	1	12	29	62	0310	3.2700					1.5800						1557	
62340	1	12	29	62	0420	1.1000	.0943	.1100	.1100	.1100	1.6900		.008			315	1558	
62340	1	12	29	62	0420							5	.024	.032		330	1559	
62340	1	12	29	62	0420							5	.024			345	1560	
62340	1	12	29	62	0420							5	.024	.048	.08	400	1561	
62340	1	12	29	62	0420							5	.024			415	1562	
62340	1	12	29	62	0452	.3200	.1125	.0600	.1700	.1700	1.7500		.027	.051		430	1563	
62340	1	12	29	62	0452							5	.029			445	1564	
62340	1	12	29	62	0452							5	.013	.042	.09	452	1565	
62340	1	12	31	62	2400	67.0800					1.7500						1566	
62340	1	12		62		21.2999					1.7500	6					1567	
62340	1			62		291.0660					42.0400	7					1568	

Figure 5. --Sample of output listed by IBM 407 accounting machine.

Last Reading in the Year

When there is no storm in progress at the end of a year and the number of hours since the last precipitation is desired, the last card should be for midnight of December 31 with a chart line depth reading of zero. In this case use type 1 trailer card.

In case a storm crosses a year the procedure below may be used.

1. Take the last reading in the year at midnight December 31. Follow this by a type 2 trailer card and two blank cards.
2. Process this year of data according to "Instructions for Operation" 1 to 9, page 14.

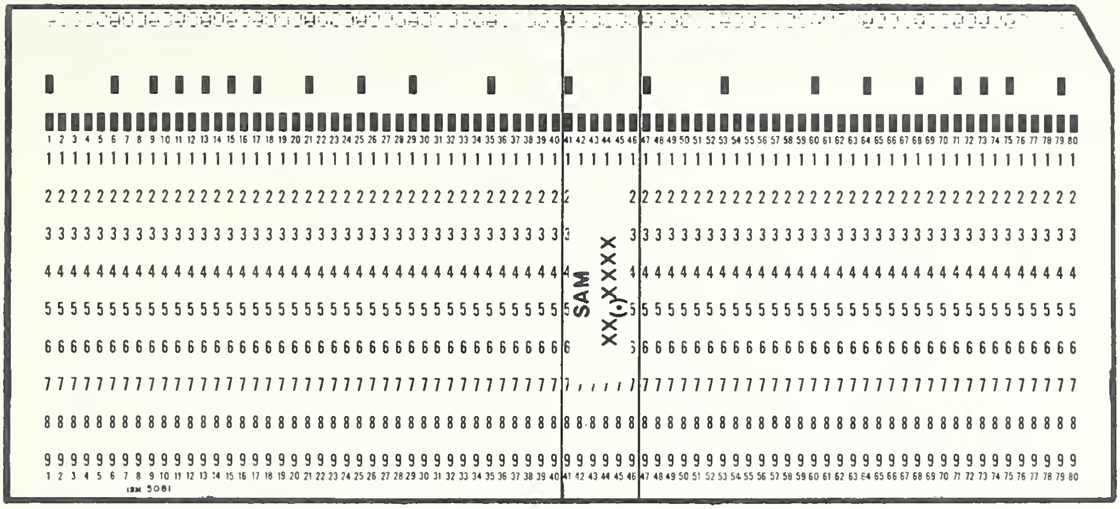


Figure 6. --Sample header card used to set up output area.

3. Immediately after processing the above data, process the data in the next year (at least until the end of the storm crossing into the following year).

4. The header card for the "new year" would be punched as shown in figure 7, except the SAM columns that would contain the storm accumulation as of midnight December 31 of the "old year." The first reading in the "new year" must be taken as if the chart line depth were zero at midnight December 31 of the "old year."

An alternate procedure would treat the storm crossing the year as two storms, i.e., one storm ending at midnight, December 31, and the other beginning at this time. To process the data using this procedure, use the steps presented below.

1. Take the last reading in the year at midnight December 31. Follow this by a type 1 trailer card and two blank cards.

2. Process this year of data according to "Instructions for Operation" 1 to 9.

3. The last part of the storm would be processed with the next year of data.

4. The first reading in the "new year" should be taken at 1 minute after midnight with the chart line depth equal to zero and other readings in the storm similarly adjusted. The remaining data in the year would be handled in the normal manner.

Speed of Operation

The speed of operation will depend on the parts used. Part 1 alone operates at punch speed, or 125 readings per minute. Parts 1 and 3, when used together, operate at punch speed. However, the extra output cards for part 3 reduce the number of readings processed per minute.

In processing 36 station years of data from Danville, Vt., when parts 1 and 2 were used, an average of 25 minutes was required to process a year of data. The input decks averaged 800 cards and covered an average of 42 storm events per year. For all three parts used at Oxford, Miss., an input deck of 850 cards required 40 minutes. The output contained 2,000 cards covering 56 storm events.

Instructions for Operation

1. Clear memory.

2. Place the compressed program deck followed by two blank cards in the reader hopper and press "LOAD."

3. After the last card is read in, depress "NON PROCESS RUNOUT" until the two blank cards come out.

4. Set the console switches as follows:

   Parity - "STOP"

   1/0 - "STOP"

   O-Flow - "STOP"

   Program switch 1 - "OFF." To omit the maximum intensity determination (part 2), place switch in "ON" position.

   Program switch 2 - "OFF." To omit the determination of precipitation amounts for regular time periods (part 3), place switch in "ON" position.

   Program switch 3--Not interrogated.

   Program switch 4--Not interrogated.

5. Place blank cards in the punch hopper.

6. Place the input data in the reader hopper in the following order:

   a. Header card
   b. Data cards
   c. Trailer card
   d. Two blank cards

7. Press "READER START" and "PUNCH START."

8. Press "START."

9. After the last card has been processed the computer will stop with the "READER NO FEED" light on. Press both "NON PROCESS RUNOUT" switches and remove all cards.

10. If you have another year of data to run, repeat steps 4 to 10 and omit step 8.

Summary

The tedious and repetitious calculations required in reducing raw precipitation data into quantities needed for analysis and reporting can be performed by an IBM 1620 computer using the program as presented. Input data for the program may be punched either manually or by an automatic chart reader.

Precise calculations are performed by the computer in determining values for three separate output sections: namely, (1) precipitation intensities and amounts of precipitation by intervals, storm, day, month, and year; (2) maximum intensities for various time periods; and (3) precipitation amounts for regular time periods. The last two sections may be bypassed as desired.

The output data are punched in cards of a form designed for re-use as "input" data to analysis and data handling programs. Each card is numbered and each type of output has a code unique to that group, so that all sorting, separation, and handling of the data may be done by machine.

APPENDIX 1

SPS SOURCE DECK LISTING FOR IBM 1620 COMPUTER

```
        DORG402
ITTFC   DC   2,0
PMTF    B    AROUND-12,,0
ORG     BNC1RETURN,,0
IN1     DS   5
IN2     DS   3
IN3     DS   4
IN4     DS   2
IN5     DS   2
IN6     DS   2
IN7     DS   4
IN8     DS   4
IN9     DS   2
IN11    DS   2
IN12    DS   4
        DS   18
        DS   28
OUT1    DS   5
OUT2    DS   3
OUT3    DS   2
OUT4    DS   2
OUT5    DS   2
OUT6    DS   6
OUT7    DS   8
OUT8    DS   6
OUT9    DS   6
OUT10   DS   6
OUT11   DS   6
OUT12   DS   7
OUT13   DS   4
OUT14   DS   4
OUT15   DS   3
OUT16   DS   4
OUT17   DS   4
OUT18   DS   2
EOUT1   DS   5
EOUT2   DS   3
EOUT3   DS   2
EOUT4   DS   2
EOUT5   DS   2
EOUT6   DS   4
EOUT7   DNB  40
EOUT8   DC   5,50000
EOUT9   DS   4
EOUT10DS     3
EOUT11DS     4
EOUT12DS     4
EOUT13DS     2
OUT19   DS   14
OUT20   DS   6
OUT21   DS   8
OUT22   DNB  24
OUT23   DS   7
OUT24   DNB  15
OUT25   DS   4
OUT26   DS   2
CODES   DC   4,6789
NO1     DC   4,0
NO2     DC   4,0
NOMO    DC   2,0
JAN     DC   2,31
FEB     DC   2,0
MAR     DC   2,31
APR     DC   2,30
MAY     DC   2,31
JUNE    DC   2,30
JULY    DC   2,31
AUG     DC   2,31
SEPT    DC   2,30
OCT     DC   2,31
NOV     DC   2,30
DEC     DC   2,31
ZERO    DC   10,0
X5      DC   4,0
X6      DC   4,0
M1      DC   3,0
DE3     DC   9,0
X2      DC   9,0
TIME    DC   8,0
YTIME   DC   8,0
YAMT    DC   6,0
TFH     DC   9,0
TIFH    DC   11,0
TT      DC   4,0
A       DC   4,0
B       DC   4,0
AMT1    DC   6,0
AMT2    DC   6,0
AMT3    DC   6,0
TCK1    DC   2,0
TCK2    DC   2,0
TCK3    DC   2,0
TI1     DC   2,15
TI2     DC   2,30
TI3     DC   2,60
DIGIT   DC   2,0
```

```
IPM   DC  6,0
CNTB  DC  2,0
REK1  DC  4,0
      DC  4,0
      DC  3,0
      DC  4,@
B3    DC  7,0
ROA   DC  7,0
TIA   DC  4,0
ANY   DC  4,0
ROAH  DC  7,0
TIAH  DC  4,0
HOLD  DC  6,0
CNT   DSA STORE-24
OUT30 DC  5,0
OUT31 DC  3,0
OUT32 DC  2,0
OUT33 DC  2,0
OUT34 DC  2,0
      DNB 8
OUT35 DC  6,0
OUT36 DC  6,0
OUT37 DC  6,0
OUT38 DC  6,0
OUT39 DC  6,0
OUT40 DC  7,0
      DNB 15
OUT41 DC  4,0
OUT42 DC  2,0
INT1  DC  4,2
      DC  4,5
      DC  4,10
      DC  4,15
      DC  4,20
      DC  4,30
      DC  4,60
      DC  4,120
      DC  4,240
      DC  4,360
      DC  4,720
      DC  4,1440
      DC  4,9999
RECORDDC  6,0
      DC  6,0
      DC  6,0
      DC  6,0
      DC  6,0
      DC  7,@
FIRST RNCDOUT1-4
      CF  EOUT8-4
```

```
      LD  92,OUT6-2
      DM  91,60,10
      TF  TFH,97
      A   TFH-7,OUT6-4
START RNCDIN1-4
      SF  IN1-4
      SF  IN2-2
      SF  IN4-1
      SF  IN5-1
      SF  IN6-1
      SF  IN8-3
      SF  IN9-1
      SF  IN11-1
      BD  *+24,OUT1-5
      B   *+72
      BD  *+24,OUT1-6
      B   MOUT
      BNC2FOUT
      BNC1SEARCH
      B   MOUT
      C   IN8,X5
      BNN NEXT
      TF  X5,IN8
NEXT  C   IN4,OUT3
      BE  NEXT1
      C   OUT3,ZERO-8
      BE  DELTA
      BNC1DELTA
      BNC2DELTA
MOUT  TF  OUT19,OUT5
      TF  OUT19-2,ZERO-8
      TF  OUT19-4,OUT3
      TF  OUT19-6,OUT2
      TF  OUT19-9,OUT1
      TF  OUT21,TIME
      TF  OUT23-1,OUT12-1
      TD  OUT23,CODES-3
      CF  OUT23
      AM  OUT17,1,8
      TF  OUT25,OUT17
      WNCDOUT19-13
      A   YTIME,TIME
      A   YAMT,OUT12-1
      TF  TIME,ZERO-2
      TF  OUT12,ZERO-3
      TF  OUT11,ZERO-4
      BD  END,OUT1-5
      BNC1RETURN
      BNC2RETURN-24
DELTA C   OUT6.ZERO-6
```

```
      BNE *+48
      CM  OUT6-4,0,10
      BNE *+24
      B   NEXT2
      TFM DE3-7,24,10
      S   DE3,TFH
      TF  TFH,ZERO-1
NEXT2 LD  98,IN6
      DM  98,40,10
      C   99,ZERO-8
      BE  NEXT3
      TFM FEB,28,10
      B   NEXT4
NEXT3 TFM FEB,29,10
NEXT4 MM  OUT3,2,9
      A   NEXT5+11,99
      MM  IN4,2,9
      SM  99,2
      AM  99,NOMO
NEXT5 A   M1,NOMO,7
      C   NEXT5+11,99
      BNE *+36
      TFM NEXT5+11,NOMO
      B   NEXT6
      AM  NEXT5+11,2
      B   NEXT5
NEXT6 SM  M1,1,9
NEXT1 CM  IN11,9,10
      BNE READER
      SF  IN7-3
      SF  IN7-1
      LD  92,IN7
      DM  91,60,10
      TF  X2,97
      A   X2-7,IN7-2
DO    A   M1,IN5
      S   M1,OUT4
      CM  M1,0,9
      BE  NEXT7+36
      TF  OUT11,ZERO-4
NEXT7 MM  M1,24,10
      SF  96
      TF  TIFH-7,99
      A   TIFH,X2
      A   TIFH,DE3
      S   TIFH,TFH
      TF  M1,ZERO-7
      TF  DE3,ZERO-1
      TF  X6,IN8
      S   X6,X5
```

```
      TF  OUT9-2,X6
      LD  89,X6
      D   93,TIFH
      AM  88,5
      TF  OUT8,87
      C   X6,ZERO-6
      BNE CHECK
      CM  TIFH-7,1,8
      BNN TESTK
CHECK CM  IN9,7,10
      BE  BREAK
      B   CONT
TESTK CM  IN9,9,10
      BE  CONT
BREAK BNC2FOUT
      BC1 RETURN
      B   SEARCH
RETURNTFM BRCH+6,SETUP
      TF  OUT10-2,X6
      B   AROUND+12
CONT  C   IN4,OUT3
      BE  AROUND
      BNC2CUDBE
      BNC1CUDBE
      B   AROUND
CUDBE TF  DELTA-13,PMTF+11
      BD  MOUT,ITTFC
      TF  DELTA-13,ORG+11
AROUNDA   OUT10-2,X6
      A   OUT11-2,X6
      A   OUT12-3,X6
      A   X5,X6
      BC1 SKIP
LOAD  TF  11,OUT8,2
      MM  TIFH,6,10
      SF  90
      AM  94,5
      NOP 93,T1-10,7
LOAD1 NOP T1,93,2
      TF  NUMBER+11,LOAD1+6,11
      AM  LOAD+6,10
      AM  LOAD1+6,10
      AM  LOAD1-1,10
      TFM LOAD1+1,26,10
      TFM LOAD1-11,21,10
SKIP  TF  OUT1,IN1
      TF  OUT2,IN2
      TF  OUT3,IN4
      TF  OUT4,IN5
      TF  OUT5,IN6
      AM  OUT17,1,8
      C   OUT9-2,ZERO-6
      BE  *+36
      AM  TIFH-2,5,8
      A   TIME,TIFH-3
      TF  OUT7-4,TIFH-7
      TF  TFH,X2
      TF  OUT6-4,X2-7
      SF  TIFH-6
      MM  TIFH-3,60,10
      AM  96,5,9
      TF  OUT7-2,95
      TF  TIFH,ZERO
      TF  TIFH-9,ZERO-8
      SF  X2-6
      MM  X2,60,10
      AM  93,5,9
      TF  OUT6-2,92
BRCH  BNC2SETUP,,2
WRITE WNCDOUT1-4
      TFM ITTFC,9,10
      B   START
END   TF  OUT19-2,ZERO-6
      TFM X5,0,8
      TF  OUT21,YTIME
      TF  OUT23-1,YAMT
      TD  OUT23,CODES-2
      TF  OUT25,OUT17
      AM  OUT25,1,8
      WNCDOUT19-13
      TF  TIME,ZERO-2
      TF  YTIME,ZERO-2
      TF  YAMT,ZERO-4
      TF  TFH,ZERO-4
      TFM OUT42,0,10
      TFM ITTFC,0,10
      B   FIRST
READERBD  HR12,IN12-3
      BNF *+36,IN7-3
      SF  IN7
      AM  IN7,1440,8
      SF  IN7-3
HERE  LD  92,IN7
      DM  91,60,10
      TF  X2,97
      B   DO
HR12  SF  IN7-3
      TD  *+23,IN12-3
      CM  *+8,01000,710
      BNE *+36
```

```
      AM  IN7,480,8
      B   HERE
      CM  HR12+35,2,10
      BNE *+36
      AM  IN7,1200,8
      B   HERE
      SM  IN7,240,8
      B   HERE
SEARCHCM  OUT10-2,25,8
      BN  CLEAR
      CM  ITTFC,9,10
      BNE CLEAR
      TF  OUT30,OUT1
      TF  OUT31,OUT2
      TF  OUT32,OUT3
      TF  OUT33,OUT4
      TF  OUT34,OUT5
      TD  OUT40,CODES
      AM  OUT42,1,10
LOOP  TF  ROA,ZERO-3
      TF  TIA,ZERO-6
ACUM  A   ROA,12,7
      AM  TIA,1,8
F1    C   TIA,T2,7
      BE  NEW
      C   TIA,INT1
      BNE ACUM
GO    TF  ROAH,ROA
      TF  K2+11,ACUM+11
      TF  C3+11,ACUM+11
      TF  SUB+11,F1+11
      TF  B3,ROA
C3    A   ROAH,12,7
K2    A   B3,12,7
REAL  S   B3,12,7
      C   B3,ROA
      BNH SMALL
      TF  ROA,B3
SMALL AM  ANY,1,8
F2    C   T2,ANY,2
      BNE BB
      AM  REAL+11,10
      AM  F2+6,10
BB    AM  TIA,1,8
SUB   C   TIA,T2,7
      BNE C1,,2
H1    AM  SUB+11,10
      AM  K2+11,10
      AM  C3+11,10
POT   C   SUB+11,LOAD1+6
```

APPENDIX 1 CONTINUED

```
      BE   XX
      B    C1,,2
C1    C    INT1+4,TIA,2
C2    BE   RE
      B    C3
NEW   AM   ACUM+11,10
      AM   F1+11,10
      C    TIA,INT1
      BNE  ACUM
      C    F1+11,LOAD1+6
      BE   XX
      B    GO
RE    TFM  SUB+18,K2
      TFM  POT+30,K2
      TF   RESUB+11,SUB+11
      TF   REK2+11,K2+11
      TF   REC3+11,C3+11
      TF   TIAH,TIA
      B    K2
XX    LD   98,ROA
JJ    D    93,INT1,7
      AM   95,5
      TF   HOLD,94
      AM   CNT,24
      TF   *+18,CNT
      B    0,,2
      NOP  0,0
STORE TF   OUT35,HOLD
      B    BET
      TF   OUT36,HOLD
      B    BET
      TF   OUT37.HOLD
      B    BET
      TF   OUT38,HOLD
      B    BET
      TF   OUT39,HOLD
      B    BET
      TF   OUT40-1,HOLD
      B    BEH,,2
BEH   TFM  CNT,STORE-24
      AM   OUT17,1,8
      TF   OUT41,OUT17
      WNCDOUT30-4
      TFM  BEH-6,FINAL
      TR   OUT35-5,RECORD-5
BET   AM   NUMBER+6,4
NUMBERCM   INT1,0,2
      BH   FINAL
      C    TIA,C1+6,11
      BNE  RESET-12
```

```
      TF   ROA,ROAH
      AM   JJ+11,4
      B    XX
      AM   C1+6,4
RESET TF   ROA,ROAH
      TF   TIA,TIAH
REK2  TFM  K2+11,0
RESUB TFM  SUB+11,0
REC3  TFM  C3+11,0,7
      TFM  SUB+18,C1
      TFM  POT+30,C1
      TFM  REAL+11,I2
      TFM  F2+6,T2
      AM   JJ+11,4
      TFM  ANY,0,8
      B    C3-12
FINAL TF   ROAH,ZERO-4
      TF   TIAH,ZERO-6
      TF   ANY,ZERO-6
      TFM  F1+11,T2
      TFM  ACUM+11,I2
      TFM  REAL+11,I2
      TFM  SUB+18,C1
      TFM  POT+30,C1
      TFM  NUMBER+6,INT1
      TFM  JJ+11,INT1
      TFM  F2+6,T2
      TFM  C1+6,INT1+4
      TFM  BEH-6,BEH
      TFM  CNT,STORE-24
      AM   OUT17,1,8
      TF   OUT41,OUT17
      TD   OUT40,CODES
      WNCDOUT30-4
CLEAR TR   OUT35-5,RECORD-5
      TF   I1,ZERO,2
      C    *-6,LOAD+6
      BE   *+36
      AM   *-30,10
      B    *-48
      TFM  *-54,I1
      TFM  LOAD1-1,T1-10
      TFM  LOAD+6,I1
      TFM  LOAD1+6,T1
      TFM  LOAD1+1,41,10
      TFM  LOAD1-11,41,10
      C    IN4,OUT3
      BE   RETURN
      CM   ITTFC,9,10
      BE   MOUT
```

APPENDIX 1 CONTINUED

```
         B    RETURN
SETUP    TFM  99,60,10
         S    99,OUT6-2
         CM   99,30,10
         BH   HOUR
         TF   TT-2,OUT6-4
         TFM  TT,30,10
         B    *+36
HOUR     TF   TT-2,OUT6-4
         TFM  TT,0,10
         TFM  BRCH+6,TRY
         TF   A-2,TT-2
         TF   A,TT
SETT1    C    A,OUT6-2
         BH   FIXT1
         BE   SETT2
         A    A,TI1,7
         B    SETT1
FIXT1    TF   99,A
         S    99,OUT6-2
         TF   TCK1,TI1,27
         S    TCK1,99,2
SETT2    AM   CNTB,1,10
         CM   CNTB,2,10
         BE   FIXT2
         BH   FIXT4
FIXT3    AM   FIXT1-13,2
         AM   FIXT1+30,2
         AM   FIXT1+35,2
         AM   FIXT1+42,2
         B    SETT1-24
FIXT2    CM   TI3,60,10
         BNE  FIXT3
         TF   TCK3,OUT6-2
FIXT4    TFM  CNTB,0,10
         TFM  FIXT1-13,TI1
         TFM  FIXT1+30,TCK1
         TFM  FIXT1+35,TI1
         TFM  FIXT1+42,TCK1
         TF   B,OUT6-2
         TF   B-2,OUT6-4
         CM   B-2,24,10
         BNE  WRITE
         TFM  B-2,0,10
         B    WRITE
TRY      LD   98,OUT8
         DM   93,60,10
         AM   97,5
         TF   IPM,96
TRY1     A    AMT1,IPM
```

```
         A    AMT2,IPM
         A    AMT3,IPM
         AM   TCK1,1,10
         AM   TCK2,1,10
         AM   TCK3,1,10
         AM   B,1,10
         CM   B,60,10
         BNE  CK1
         AM   B-2,1,10
         TFM  B,0,10
CK1      C    TCK1,TI1
         BNE  CK2
         TD   DIGIT,CODES
         TFM  TCK1,0,10
         SF   AMT1-4
         AM   AMT1,5,9
TF1      TF   OUT13,AMT1-1,2
         TF   AMT1,ZERO-4
CK2      C    TCK2,TI2
         BNE  CK3
         TD   DIGIT,CODES
         TFM  TCK2,0,10
         SF   AMT2-4
         AM   AMT2,5,9
TF2      TF   OUT14,AMT2-1,2
         TF   AMT2,ZERO-4
CK3      C    TCK3,TI3
         BNE  CK4
         TD   DIGIT,CODES
         TFM  TCK3,0,10
         SF   AMT3-4
         AM   AMT3-1,5,9
TF3      TF   OUT15,AMT3-2,2
         TF   AMT3,ZERO-4
CK4      BD   CK5,DIGIT
         B    GOON
CK5      TF   OUT16-2,B-2,2
TF4      TF   OUT16,B,2
BRDG     BD   PCH1,DIGIT,2
GOON     C    B-2,OUT6-4
         BN   TRY1
         C    B,OUT6-2
         BNE  TRY1
         CM   B-2,24,10
         BNE  CLEAN1
         TFM  B-2,0,10
         TFM  B,0,10
CLEAN1BD      *+24,DIGIT-1
         B    WRITE
         TD   DIGIT,ZERO
```

```
        TD   DIGIT-1,ZERO
        TFM  TF1+6,OUT13
        TFM  TF2+6,OUT14
        TFM  TF3+6,OUT15
        TFM  CK5+6,OUT16-2
        TFM  TF4+6,OUT16
        TFM  BRDG+6,PCH1
        B    START
PCH1    WNCDOUT1-4,,2
        TR   OUT13-3,REK1-3
        TD   OUT16,ZERO
        TD   DIGIT-1,CODES
        TD   DIGIT,ZERO
        TFM  TF1+6,EOUT8
        TFM  TF2+6,EOUT9
        TFM  TF3+6,EOUT10
        TFM  CK5+6,EOUT11-2
        TFM  TF4+6,EOUT11
        TFM  BRDG+6,PCH2
        B    GOON
PCH2    TF   EOUT1,OUT1
        TF   EOUT2,OUT2
        TF   EOUT3,OUT3
        TF   EOUT4,OUT4
        TF   EOUT5,OUT5
        TF   EOUT6-2,OUT6-4
        TF   EOUT6,OUT6-2
        AM   OUT17,1,8
        TF   EOUT12,OUT17
        WNCDEOUT1-4
        TR   EOUT8-3,REK1-3
        TD   EOUT11,ZERO
        TD   DIGIT,ZERO
        B    GOON,,2
FOUT    CM   ITTFC,9,10
        BNE  CLEAN
        C    AMT1,ZERO-4
        BNE  *+60
        C    AMT2,ZERO-4
        BNE  *+36
        C    AMT3,ZERO-4
        BE   CLEAN
```

```
        SF   AMT1-4
        AM   AMT1,5,9
        TF   EOUT8,AMT1-1
        SF   AMT2-4
        AM   AMT2,5,9
        TF   EOUT9,AMT2-1
        SF   AMT3-4
        AM   AMT3-1,5,9
        TF   EOUT10,AMT3-2
        TF   EOUT11-2,B-2
        TF   EOUT11,B
        TFM  TCK1,0,10
        TFM  TCK2,0,10
        TFM  TCK3,0,10
        TF   AMT1,ZERO-4
        TF   AMT2,ZERO-4
        TF   AMT3,ZERO-4
        TFM  FOUT-6,CLEAN
        B    PCH2
CLEAN   TD   DIGIT,ZERO
        TFM  TF1+6,OUT13
        TFM  TF2+6,OUT14
        TFM  TF3+6,OUT15
        TFM  CK5+6,OUT16-2
        TFM  TF4+6,OUT16
        TFM  BRDG+6,PCH1
        TFM  FOUT-6,GOON
        TFM  BRCH+6,SETUP
        C    IN4,OUT3
        BE   RETURN-24
        CM   ITTFC,9,10
        BNE  RETURN-24
        BC1  MOUT
        B    RETURN-24
T1      DC   4,0
I1      DC   6,0
T2      DC   4,0
I2      DC   6,0
        DENDFIRST
```

APPENDIX 2

SPS COMPRESSED DECK LISTING FOR IBM 1620 COMPUTER

```
360007200500360020100500440001200276260005900274250001100000260009000269   +0000
2600095002643100000000200260011400274250000000011490001200000              +0001
+0‡                                                          1+1+0402+0404 +0002
M90269600000M70257600100‡                                    0+1+0404+0428 +0003
      @@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@‡               -7+0606+0646 +0004
N0000‡                                                       1+1+0646+0651 +0005
      @@@@@@@@@@@@@@@@@@@@@@@@‡                               -7+0696+0720 +0006
      @@@@@@@@@@@@@@@‡                                        -7+0727+0742 +0007
ø789+000+000+0L1+0L1L0L1L0L1L1L0L1L0L1+000000000+000+000+00‡ 1+1+0748+0807 +0008
+00000000+00000000+0000000+0000000+00000+00000000+0000000000‡1+1+0807+0867 +0009
+000+000+000+00000+00000+00000+0+0+0J5L0ø0+0+00000+0+000+000‡1+1+0867+0927 +0010
+00+00‡                                                      1+1+0927+0934 +0011
+000000+000000+000+000+000000+000+00000‡                     1+1+0934+0973 +0012
+4472‡                                                       1+1+0973+0978 +0013
+0000+00+0+0+0‡                                              1+1+0978+0992 +0014
      @@@@@@@@‡                                               -7+0992+1000 +0015
+00000+00000+00000+00000+00000+000000‡                       1+1+1000+1037 +0016
      @@@@@@@@@@@@@@@‡                                        -7+1037+1052 +0017
+000+0+002+005+010+015+020+030+060+120+240+360+720J440R999‡  1+1+1052+1110 +0018
+00000+00000+00000+00000+00000+00000‡                        1+1+1110+1147 +0019
360050800500330064600000280009200525190009100000260085500097‡0+1+1148+1208 +0020
210084800523360042800500320042800000320043300000320044000000‡0+1+1208+1268 +0021
320044200000320044400000320045000000320045400000320045600000‡0+1+1268+1328 +0022
430135200507490141200000430137600506490152000000470698000200‡0+1+1328+1388 +0023
470366800100490152000000240045300799460144801300260079900453‡0+1+1388+1448 +0024
240044100517460209601200240051700787460176001200470176000100‡0+1+1448+1508 +0025
470176000200260068100521260067900787260067700517260067500515‡0+1+1508+1568 +0026
260067200512260069500832260072500565250072600748330072600000‡0+1+1568+1628 +0027
11005850+00126007450058538006680040021008400083221008460056 5‡0+1+1628+1688 +0028
260083200793260056600792260055900791430323600507470257600100‡0+1+1688+1748 +0029
4702552002002400527007894701820012001400523000+0470182001200‡0+1+1748+1808 +0030
490185600000160080800 0K42200815008552600855007942800098004 45‡0+1+1808+1868 +0031
```

NOTE: A FLAGGED ZERO ($\bar{0}$) IS PRINTED AS +; A FLAGGED SIX ($\bar{6}$) IS PRINTED AS ø.

APPENDIX 2 CONTINUED

```
1900098000M02400099007874601928012001600765000K8490194000000‡0+1+1868+1928  +0032
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1100099+07612100806+07612402011000994702060012001602011+0761‡0+1+1988+2048  +0034
4902084000001102011+00024902000000001200806 00+011400457000+9‡0+1+2048+2108  +0035
470341601200320044600000320044800000280009200449190009100000‡0+1+2108+2168  +0036
260082400097210081700447210080600443220080600519140080600+00‡0+1+2168+2228  +0037
460228801200260055900791130080600 0K4320009600000260085900099‡0+1+2228+2288  +0038
210086600824210086600815220086600855260080600788260081500794‡0+1+2288+2348  +0039
260080300453220080300799260054500803280008900803290009300866‡0+1+2348+2408  +0040
1100088+000526005410008724008030078947024800120014008590+001‡0+1+2408+2468  +0041
4602516013001400455000+7460254001200490261200000140045 5000+9‡0+1+2468+2528  +0042
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470267200100490270800000260174700415430152000403260174700427‡0+1+2648+2708  +0045
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26+7493005411300866000+632000900000011000094+00054100093+7477‡0+1+2768+2828  +0047
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26005190044326005210044511005850+0012400545007894603032 01200‡0+1+2948+3008  +0050
1100864 0+005210083200863260053100859260085500824260052300817‡0+1+3008+3068  +0051
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260085700787320081800000130082400000110009300+05260052500092‡0+1+3128+3188  +0053
47+538400200380050800400160040300 0+9490122000000260067900789‡0+1+3188+3248  +0054
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11007450+001380066800400260083200793260084000793260084600791‡0+1+3308+3368  +0056
26008550079116010570 00+0160040300 0+049011480000043035240045 8‡0+1+3368+3428  +0057
4403464004463200449000001100449 0J4403200446000002800092004 49‡0+1+3428+3488  +0058
190009100000260082400097490219200000320044600000250355900458‡0+1+3488+3548  +0059
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14005510+025470518001300140040300 0+947051800120026009820051 2‡0+1+3668+3728  +0062
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1101057000+126009470079226009510078921009 47+7503110095 10+001‡0+1+3788+3848  +0064
2400951+749746042320120024009510106147038240120026009620 0947‡0+1+3848+3908  +0065
26039790383526039670383526041110385926009400094721009 62+7503‡0+1+3908+3968  +0066
2100940+75032200940+7503240094000947470402801100260094700940‡0+1+3968+4028  +0067
```

APPENDIX 2 CONTINUED

```
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1103967+0010240411102834460440001200049+41960000024+106500951‡0+1+4148+4208  +0070
46043160120049039560000011103835+00101103859+00102400951 01061‡0+1+4208+4268  +0071
4703824012002403859028344604400012004903896000001604118+3968‡0+1+4268+4328  +0072
1604190+396826048670411126048550397926048790396726009660095l‡0+1+4328+4388  +0073
4903968000002800098009472900093+1061 1100095+0005260097200094‡0+1+4388+4448  +0074
1100977+00242604478009774 9+000000000410000000000260100500972‡0+1+4448+4508  +0075
490471200000260101100972490471200000260101700972490471200000‡0+1+4508+4568  +0076
260102300972490471200000260102900972490471200000260103500972‡0+1+4568+4628  +0077
49+46400000016009 77+44721 1005850+00126010550058538009 7800400‡0+1+4628+4688  +0078
1604634+4964310100001110 1104730+000414+106100000460496401100‡0+1+4688+4748  +0079
24009510420K4704808012002600947009621104423+000449044 0000000‡0+1+4748+4808  +0080
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1104423+00041600955 0+000490394400000260096200791260096600789‡0+1+4928+4988  +0083
2600955007891603859+74971603835+75031603991+75031604118+4196‡0+1+4988+5048  +0084
1604190+41961604730+10611604423+10611604046+74971604202+1065‡0+1+5048+5108  +0085
1604634+46401600977+44721 1005850+0012601055005852501036007 51‡0+1+5108+5168  +0086
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1100900000+11100902000+11100878000+11400878000004706092 01200‡0+1+6008+6068  +0101
1100876000+11600878000+024008980090447061880120025009100075 1‡0+1+6068+6128  +0102
1600898000+032008800000011008840 0+0526+057000883260088400791‡0+1+6128+6188  +0103
```

APPENDIX 2 CONTINUED

```
2400900009064706284012002500910007511600900000+0320088600000‡0+1+6188+6248  +0104
110089000+0526+057400889260089000791240090200908470638001200‡0+1+6248+6308  +0105
2500910007511600902000+0320089200000110089500+0526+057700894‡0+1+6308+6368  +0106
260089600791430640400910490644000000026+05790087626+058100878‡0+1+6368+6428  +0107
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1400876000K44706536012001600876000+01600878000+0430656000909‡0+1+6488+6548  +0109
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38+050800400310056700919250058100795250090900751250091000795‡0+1+6668+6728  +0112
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1606974+64401603194+53842400441005174602552012001400403000+9‡0+1+7388+7448  +0124
470255201200460152000100490255200000‡                        0+1+7448+7484  +0125
+000+00000+000+00000‡                                        1+1+7484+7504  +0126
00000   L600000005004900000‡                                  +8+0096+0115  +0127
3600100005003600172005003600244005003600316005003600000000500               +0128
000000000000102030400020406080003060902100408021610050015102006021814200‡   +0129
70411282008061422300908172630000000005060708090012141618151811242720242‡   +0130
822363520353045403632484455324946536048465462754453627180123456789123456‡   +0131
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```
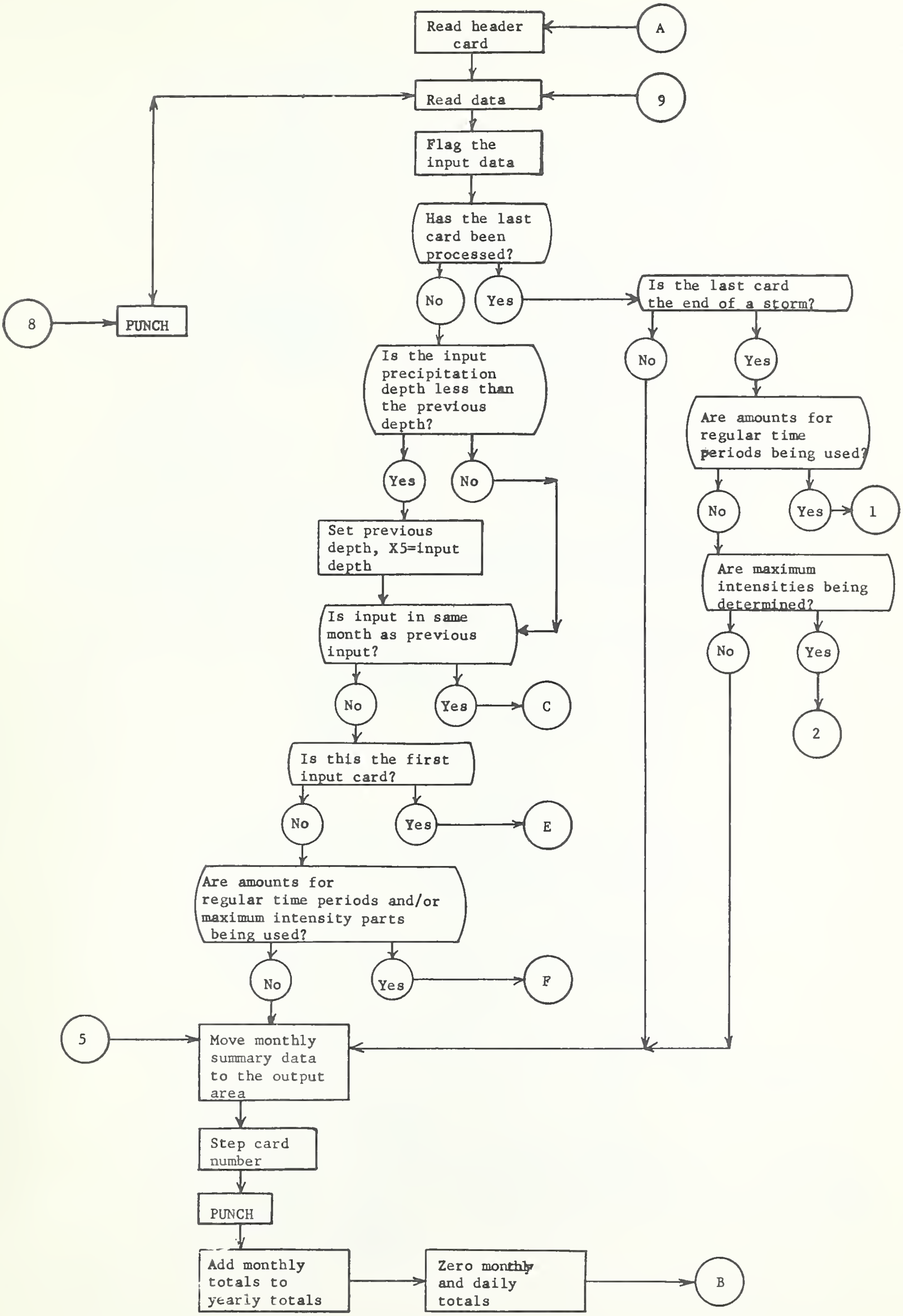
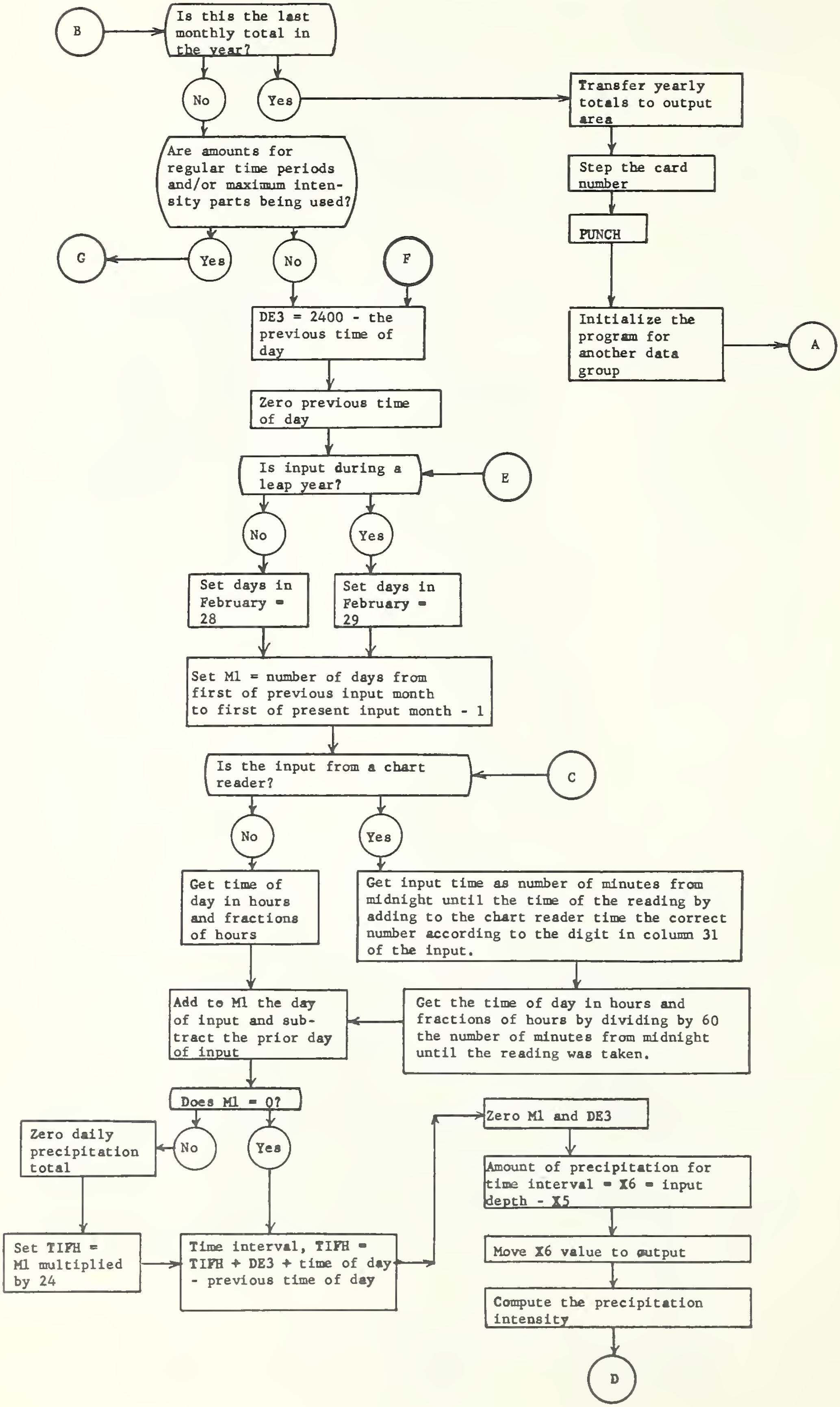
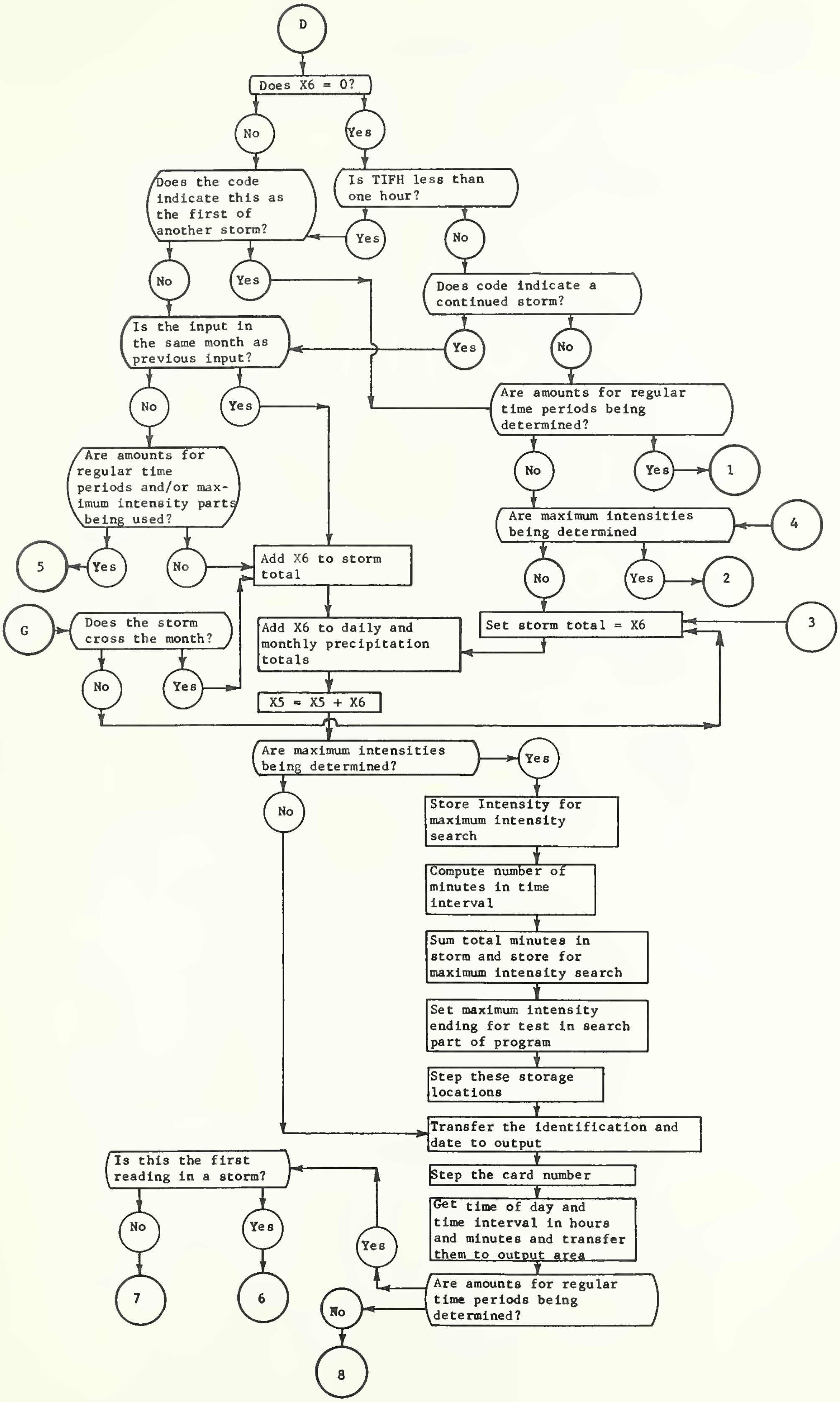
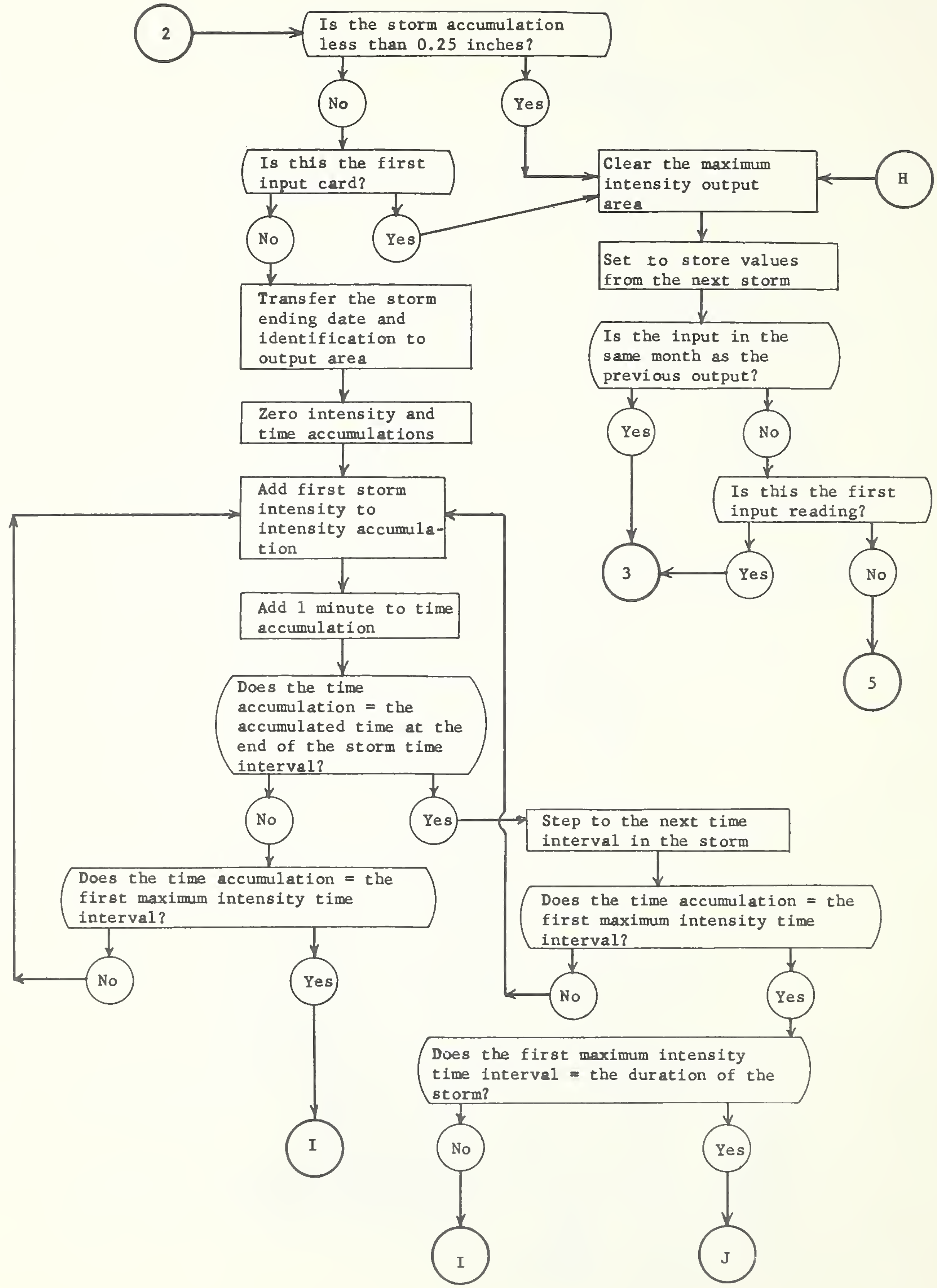
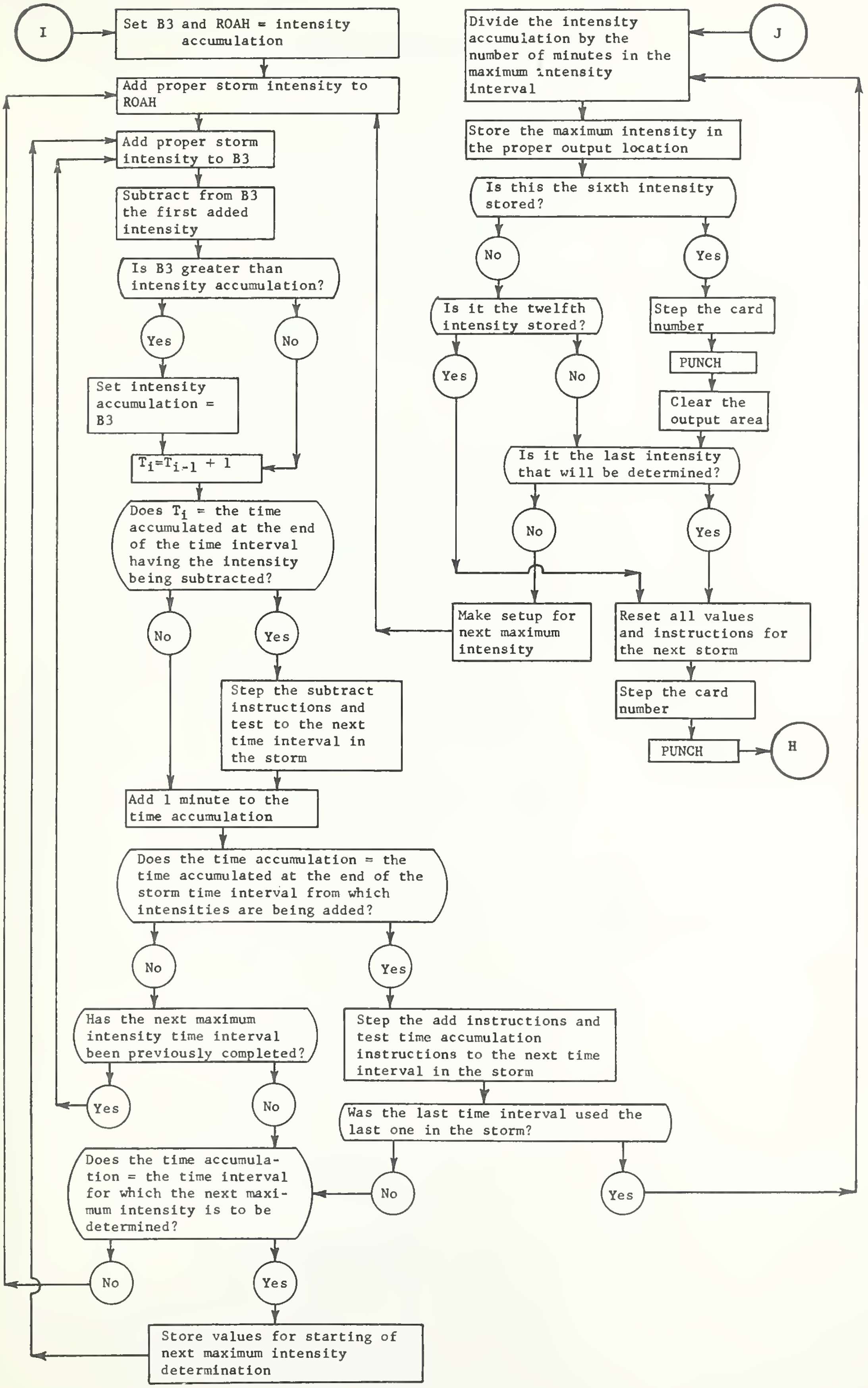
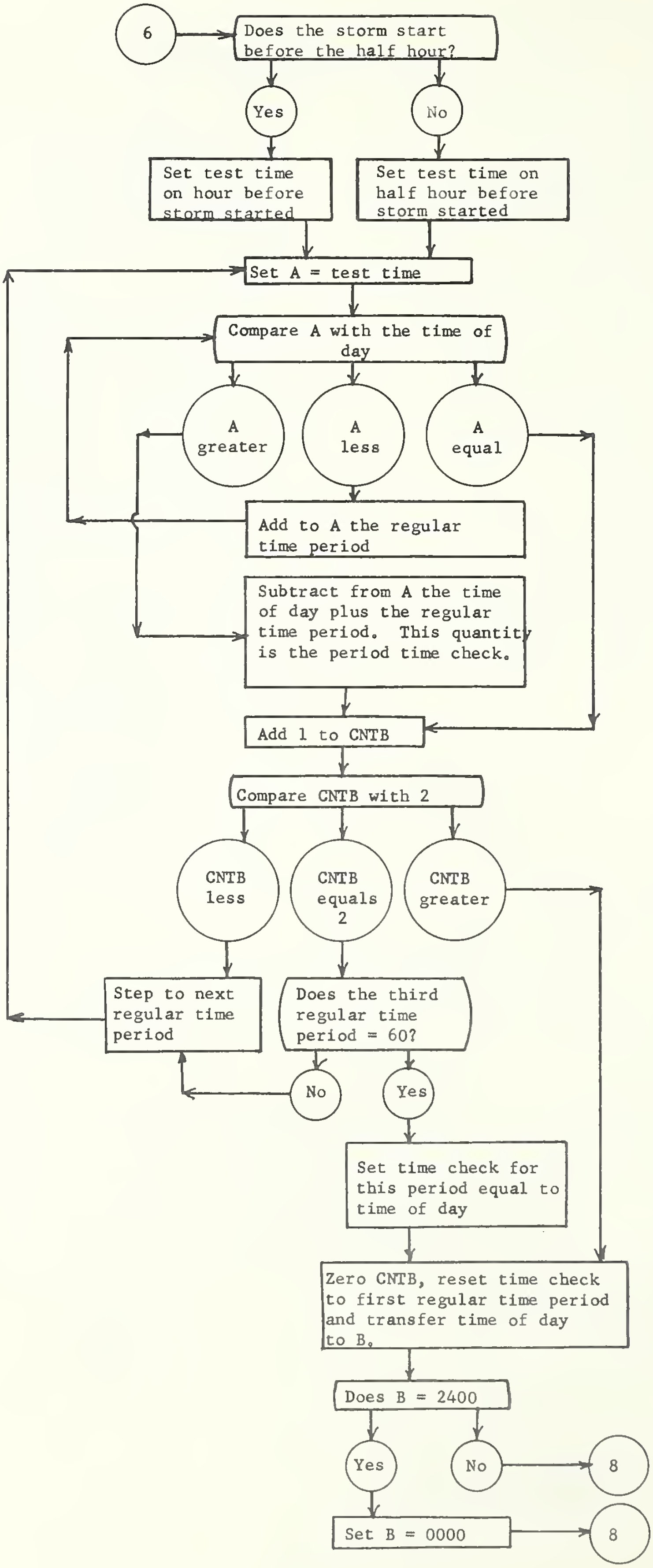


Read header card
A
Read data
9
Flag the input data
Has the last card been processed?
No
Yes
Is the last card the end of a storm?
8
PUNCH
Is the input precipitation depth less than the previous depth?
No
Yes
Are amounts for regular time periods being used?
Yes
No
Set previous depth, X5=input depth
No
Yes
1
Are maximum intensities being determined?
Is input in same month as previous input?
No
Yes
No
Yes
C
2
Is this the first input card?
No
Yes
E
Are amounts for regular time periods and/or maximum intensity parts being used?
No
Yes
F
5
Move monthly summary data to the output area
Step card number
PUNCH
Add monthly totals to yearly totals
Zero monthly and daily totals
B

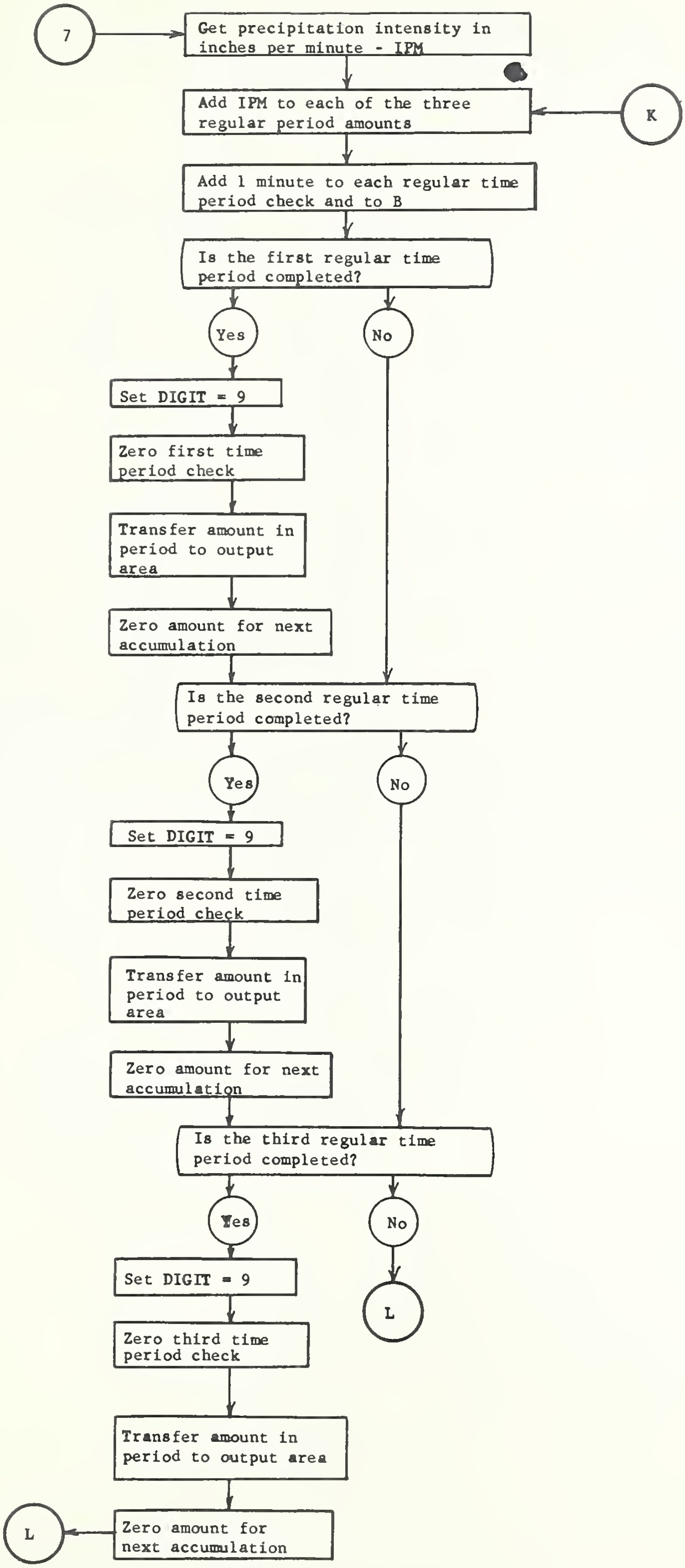

B
Is this the last monthly total in the year?
No
Yes
Transfer yearly totals to output area
Step the card number
PUNCH
Initialize the program for another data group
A
Are amounts for regular time periods and/or maximum intensity parts being used?
G
Yes
No
F
DE3 = 2400 - the previous time of day
Zero previous time of day
Is input during a leap year?
E
No
Yes
Set days in February = 28
Set days in February = 29
Set M1 = number of days from first of previous input month to first of present input month - 1
Is the input from a chart reader?
C
No
Yes
Get time of day in hours and fractions of hours
Get input time as number of minutes from midnight until the time of the reading by adding to the chart reader time the correct number according to the digit in column 31 of the input.
Add to M1 the day of input and subtract the prior day of input
Get the time of day in hours and fractions of hours by dividing by 60 the number of minutes from midnight until the reading was taken.
Does M1 = 0?
Zero daily precipitation total
No
Yes
Zero M1 and DE3
Amount of precipitation for time interval = X6 = input depth - X5
Set TIFH = M1 multiplied by 24
Time interval, TIFH = TIFH + DE3 + time of day - previous time of day
Move X6 value to output
Compute the precipitation intensity
D

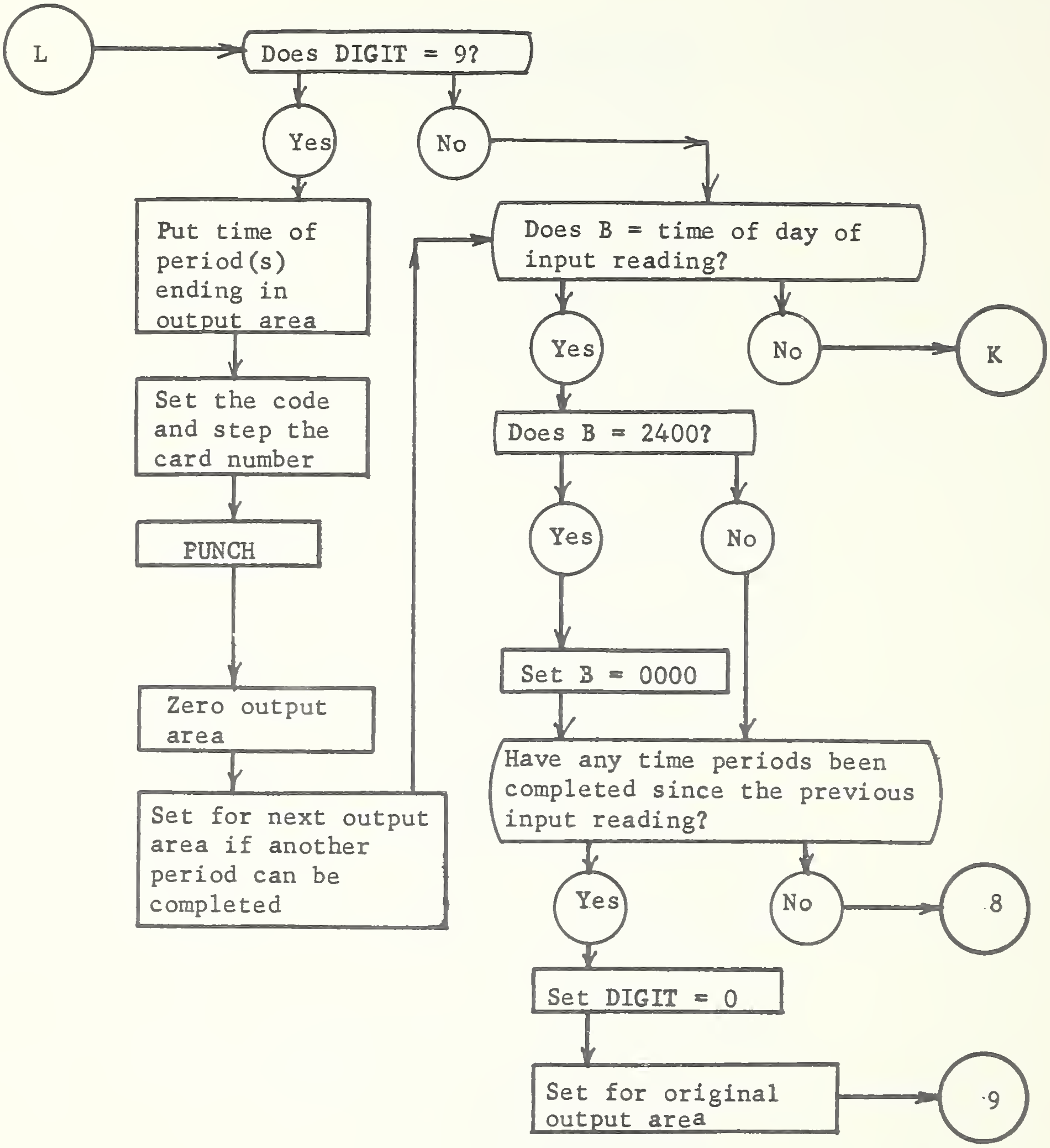

D
Does X6 = 0?
No
Yes
Is TIFH less than one hour?
Does the code indicate this as the first of another storm?
Yes
No
No
Yes
Does code indicate a continued storm?
Is the input in the same month as previous input?
Yes
No
No
Yes
Are amounts for regular time periods being determined?
Are amounts for regular time periods and/or maximum intensity parts being used?
No
Yes
1
Are maximum intensities being determined
4
5
Yes
No
Add X6 to storm total
No
Yes
2
Set storm total = X6
3
G
Does the storm cross the month?
Add X6 to daily and monthly precipitation totals
No
Yes
X5 = X5 + X6
Are maximum intensities being determined?
Yes
No
Store Intensity for maximum intensity search
Compute number of minutes in time interval
Sum total minutes in storm and store for maximum intensity search
Set maximum intensity ending for test in search part of program
Step these storage locations
Transfer the identification and date to output
Is this the first reading in a storm?
Step the card number
No
Yes
Get time of day and time interval in hours and minutes and transfer them to output area
Yes
7
6
Are amounts for regular time periods being determined?
No
8

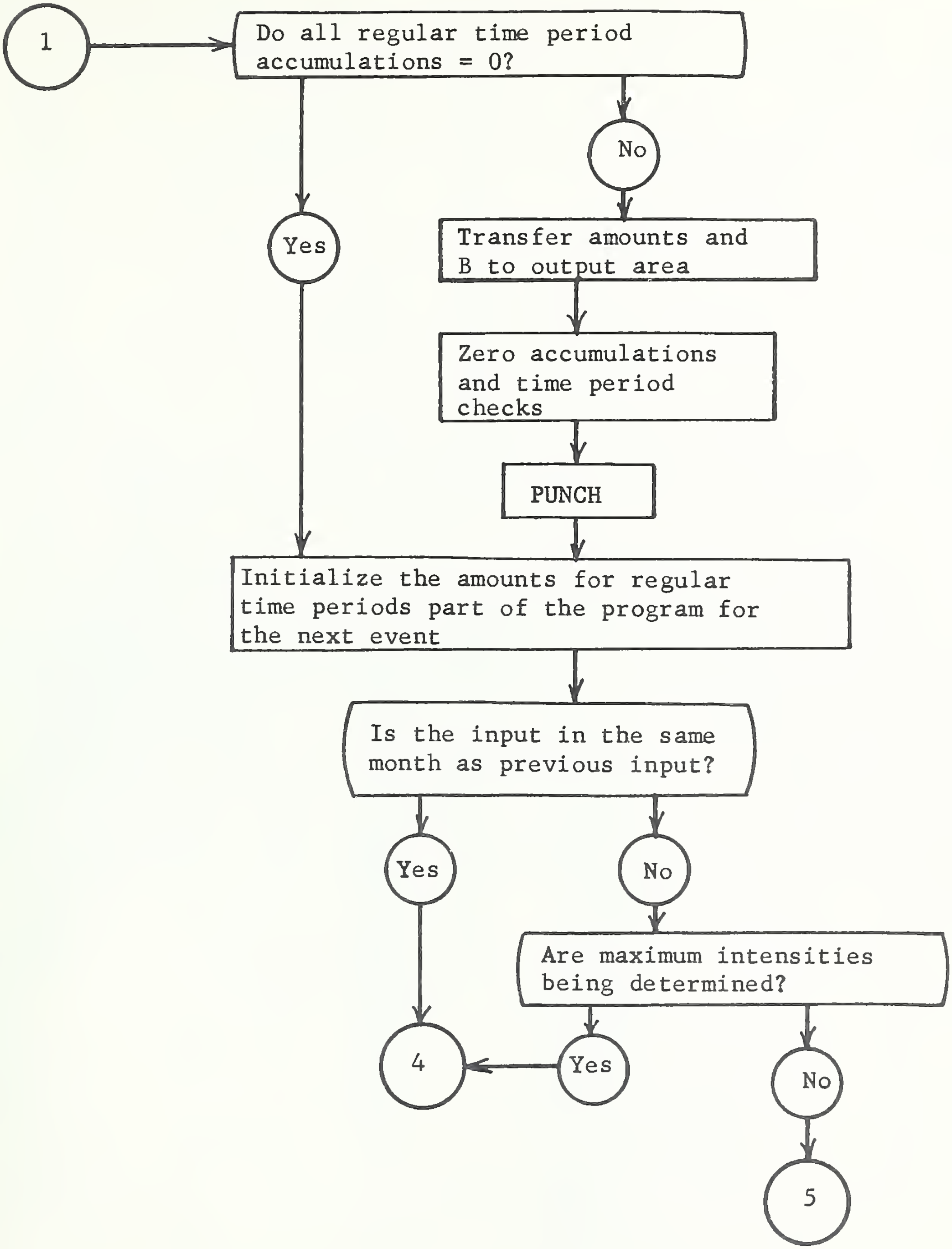

2
Is the storm accumulation less than 0.25 inches?
No
Yes
Is this the first input card?
No
Yes
Clear the maximum intensity output area
H
Set to store values from the next storm
Transfer the storm ending date and identification to output area
Is the input in the same month as the previous output?
Yes
No
Zero intensity and time accumulations
Is this the first input reading?
Add first storm intensity to intensity accumulation
3
Yes
No
Add 1 minute to time accumulation
5
Does the time accumulation = the accumulated time at the end of the storm time interval?
No
Yes
Step to the next time interval in the storm
Does the time accumulation = the first maximum intensity time interval?
Does the time accumulation = the first maximum intensity time interval?
No
Yes
No
Yes
Does the first maximum intensity time interval = the duration of the storm?
I
No
Yes
I
J


I
Set B3 and ROAH = intensity accumulation
Add proper storm intensity to ROAH
Add proper storm intensity to B3
Subtract from B3 the first added intensity
Is B3 greater than intensity accumulation?
Yes
No
Set intensity accumulation = B3
$T_i = T_{i-1} + 1$
Does T_i = the time accumulated at the end of the time interval having the intensity being subtracted?
No
Yes
Step the subtract instructions and test to the next time interval in the storm
Add 1 minute to the time accumulation
Does the time accumulation = the time accumulated at the end of the storm time interval from which intensities are being added?
No
Yes
Has the next maximum intensity time interval been previously completed?
Yes
No
Step the add instructions and test time accumulation instructions to the next time interval in the storm
Was the last time interval used the last one in the storm?
No
Yes
Does the time accumulation = the time interval for which the next maximum intensity is to be determined?
No
Yes
Store values for starting of next maximum intensity determination
J
Divide the intensity accumulation by the number of minutes in the maximum intensity interval
Store the maximum intensity in the proper output location
Is this the sixth intensity stored?
No
Yes
Is it the twelfth intensity stored?
Yes
No
Step the card number
PUNCH
Clear the output area
Is it the last intensity that will be determined?
No
Yes
Make setup for next maximum intensity
Reset all values and instructions for the next storm
Step the card number
PUNCH
H

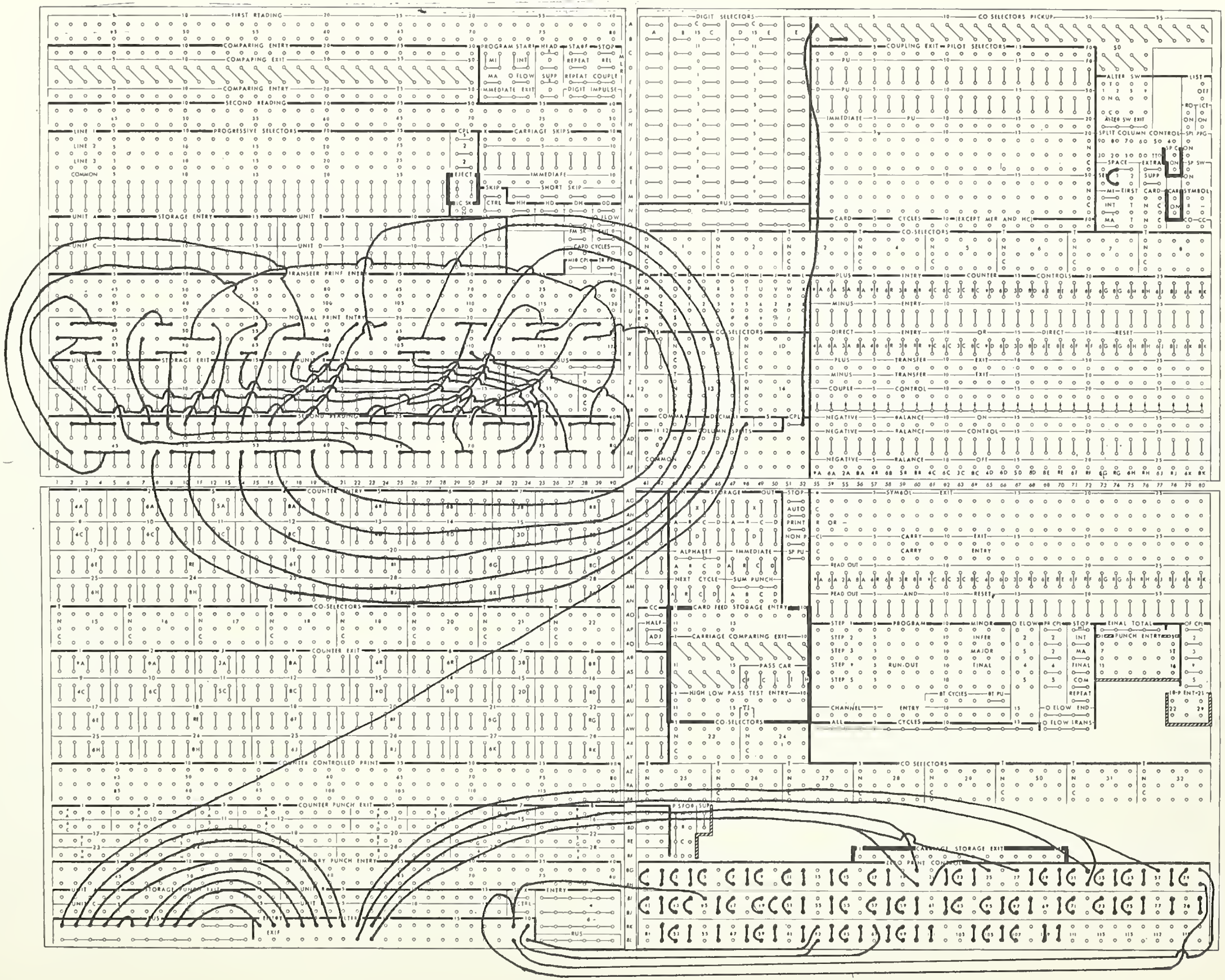

6
Does the storm start before the half hour?
Yes
No
Set test time on hour before storm started
Set test time on half hour before storm started
Set A = test time
Compare A with the time of day
A greater
A less
A equal
Add to A the regular time period
Subtract from A the time of day plus the regular time period. This quantity is the period time check.
Add 1 to CNTB
Compare CNTB with 2
CNTB less
CNTB equals 2
CNTB greater
Step to next regular time period
Does the third regular time period = 60?
No
Yes
Set time check for this period equal to time of day
Zero CNTB, reset time check to first regular time period and transfer time of day to B.
Does B = 2400
Yes
No
8
Set B = 0000
8


7
Get precipitation intensity in inches per minute - IPM
Add IPM to each of the three regular period amounts
K
Add 1 minute to each regular time period check and to B
Is the first regular time period completed?
Yes
No
Set DIGIT = 9
Zero first time period check
Transfer amount in period to output area
Zero amount for next accumulation
Is the second regular time period completed?
Yes
No
Set DIGIT = 9
Zero second time period check
Transfer amount in period to output area
Zero amount for next accumulation
Is the third regular time period completed?
Yes
No
Set DIGIT = 9
L
Zero third time period check
Transfer amount in period to output area
L
Zero amount for next accumulation

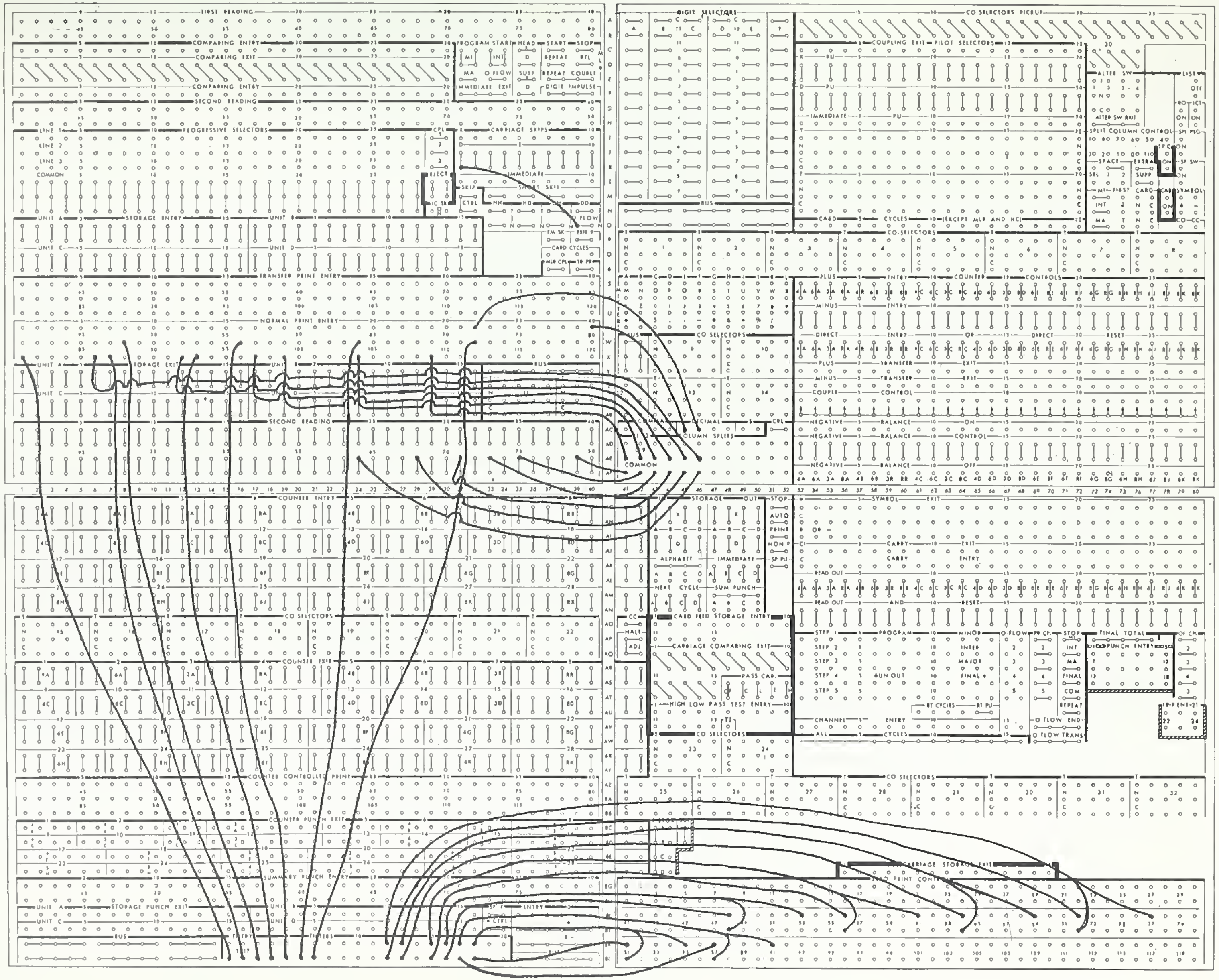

L
Does DIGIT = 9?
Yes
No
Put time of period(s) ending in output area
Set the code and step the card number
PUNCH
Zero output area
Set for next output area if another period can be completed
Does B = time of day of input reading?
Yes
No
K
Does B = 2400?
Yes
No
Set B = 0000
Have any time periods been completed since the previous input reading?
Yes
No
8
Set DIGIT = 0
Set for original output area
9


1
Do all regular time period accumulations = 0?
Yes
No
Transfer amounts and B to output area
Zero accumulations and time period checks
PUNCH
Initialize the amounts for regular time periods part of the program for the next event
Is the input in the same month as previous input?
Yes
No
Are maximum intensities being determined?
4
Yes
No
5

APPENDIX 4



APPENDIX 4-Continued.



APPENDIX 4-Continued.